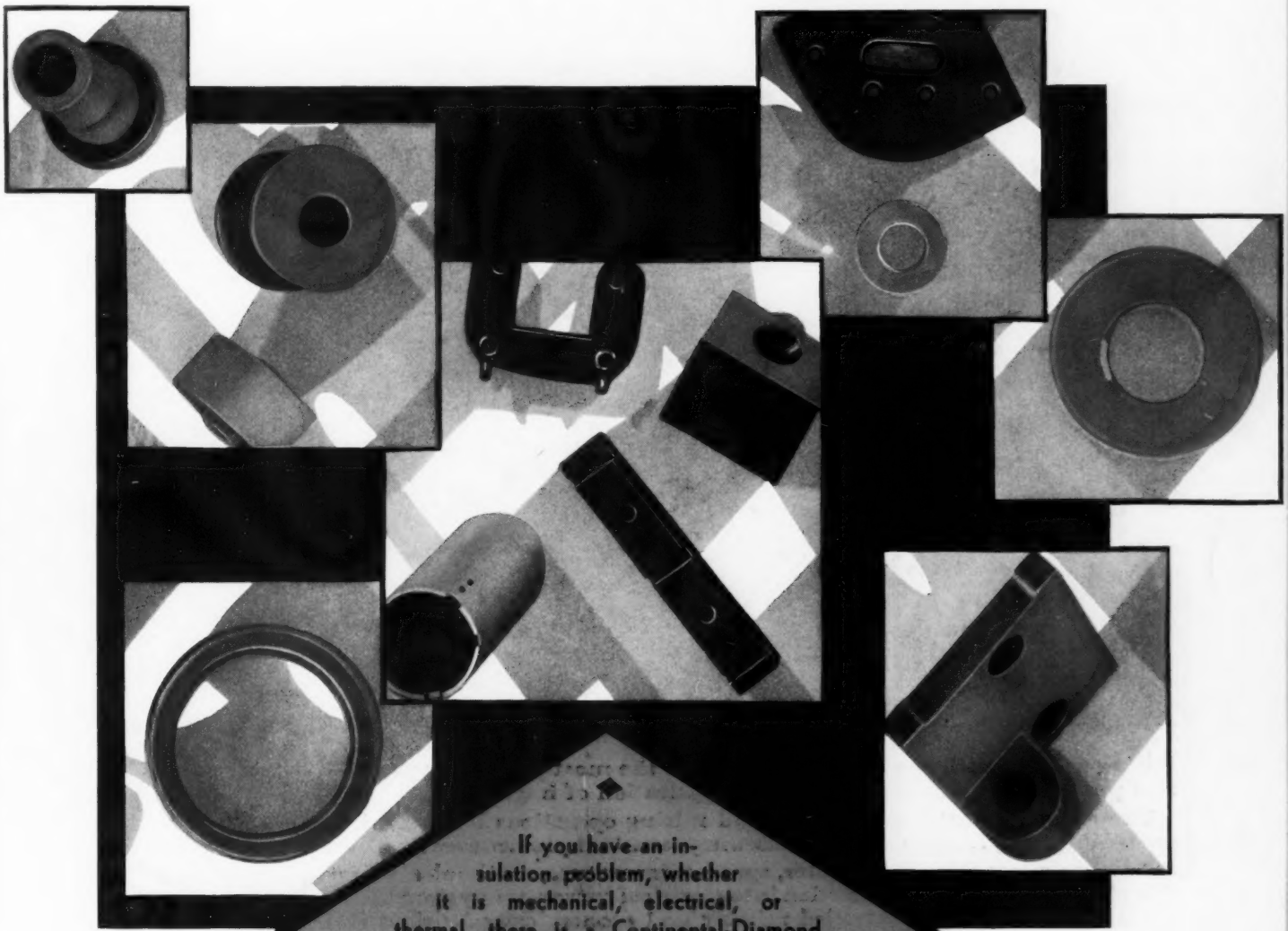
Engineering Library

ELECTRICAL WORLD

AUG 22 1932

McGraw-Hill Publishing Company, Inc.

AUGUST 20, 1932
25 cents per copy



If you have an insulation problem, whether it is mechanical, electrical, or thermal, there is a Continental-Diamond insulating material to meet your particular requirements. VULCOID — an economical, tough, resilient, moisture and water resisting, laminated fibrous insulating material; DILECTO — a laminated phenolic material; DIAMOND FIBRE — a hard, dense vulcanized fibre; MICABOND — mica sheets, tubes, punched, machined, and formed parts; CELLANITE — a laminated non-phenolic odorless thermal and electrical insulating material; and CELORON molded parts and silent gears. ◆ For prompt service to manufacturers fabricating their own parts, stocks of standard forms — sheets, rods, tubes — are carried in conveniently located warehouses. Fabricated parts can be supplied from our own factories in Valparaiso, Indiana; Newark, Delaware; and Toronto, Canada. ◆ Continental-Diamond engineers will be glad to work with you to determine the material best suited to your needs. Catalogs supplied without obligation.

CONTINENTAL-DIAMOND
FIBRE COMPANY
NEWARK, DELAWARE

TOOLS of Production

During recent years, the answers to some of the most perplexing production problems have been found in the application of instruments.

The output of cutting, grinding and mixing operations has been improved in quality . . . and costly breakdowns prevented by instrument control.

By translating noise, light, color, speed, temperature, mechanical vibration, tension, viscosity and friction into electrical energy, many production operations have been controlled reliably and economically by electrical instruments. Guess work and human error are eliminated. The quality of the output improved.

In practically every form of production, thousands of electrical instruments testify to the time, labor and material that have been saved through instrument control. And many of these installations are the result of the combined effort of the manufacturers and the Weston Research Engineers.

And Weston stands ready to help you—to lend their broad experience and intimate knowledge of instrument operation to the application of this new instrument control to your production problems.

YOUR CORRESPONDENCE HELD IN STRICT CONFIDENCE

WESTON
ELECTRICAL INSTRUMENT CORP.
578 FRELINGHUYSEN AVENUE NEWARK, N. J.

ELECTRICAL WORLD

Established 1883. McGraw-Hill Publishing Company, Inc.

for the Week Ending

August 20, 1932

Pinchot Goads Pennsylvania Senate to Regulatory Investigation

THOUGH Chairman Ainey and three-fifths of Pennsylvania's Public Service Commission resigned and the state Senate had indicated a willingness to thereupon let the matter and all the sensational charges drop, Governor Gifford Pinchot continues to seek action to discredit regulation in that state.

Governor Pinchot's specific demand is for an inquiry which would review "the system by which the public ultilities have controlled the Public Service Commission and have established the rates and charges the commission has allowed them to levy and collect."

"There is the strongest reason why the investigation should be made at once," the Governor said in a personal appearance before the Senate last week. "There is no doubt that as soon as the payment of Ainey's hospital bill by Thompson became known certain public utility officials hastened to learn exactly what their books show about their relations to the Public Service Commission. To conceal or alter damaging entries in the books was their purpose."

Commissioner Benn assailed

Subsequently it was charged that former Public Service Commissioner James S. Benn deposited $650,000 in Philadelphia banks during the ten years he served on the commission, when his salary aggregated only $100,000 for the period.

In one year the deposits totaled $150,000 and in three years $375,000, "or more than twice as much in three years as W. D. B. Ainey, former chairman of the commission, was known to have deposited in five years," the Governor said.

That a long-standing disagreement on regulatory matters between Pinchot and the Pennsylvania Republican organization had at last been broken down was evidenced by the statement of Edward Martin, Republican state chairman, who this week said:

"I have been asked what I think about the Public Service Commission. The Republican organization of Pennsylvania throughout the years has always stood for the highest governmental standards. In my opinion the time has come for the Senate to undertake a full and impartial inquiry into the Public Service Commission from its inception, and report its findings to the regular session of 1933, which is only a little more than four months away."

A resolution authorizing a legislative inquiry covering eighteen years of the Public Service Commission's relations with public utilities was presented to the Senate on Wednesday and at the time of going to press was in the hands of the appropriations committee.

This Week

Air-conditioning division organized at Westinghouse. p. 227

Gaseous discharge lamps light streets in Holland. p. 233

Interim rate reductions secured in Wisconsin. p. 228

Angle of suspension used to test sag of lines. p. 227

West Virginia commission balks at legislative order. p. 227

Associated plea denied by New York commission. p. 227

Penn Central receivership plea dismissed by court p. 226

▼

Vacuum Tubes Control 3,500-Lb. Steam Boilers

Higher and higher go operating pressures in commercial generating stations. Perhaps the control evolved for 3,500-lb. pressure, 830-deg. F. experimental steam boilers at Purdue University may be necessary elsewhere. Three-element gaseous tubes are used and so arranged that two thyratrons are connected to a reversing pilot motor. One tube will operate the motor in one direction while the other tube will run it in the reverse direction.

The motors controlling the oil throttle valve and the boiler-feed-pump rheostat are plugged when the system is in balance; that is, each motor is supplied with current from two thyratrons at the same time, with the result that it receives an alternating current which is limited by a choke-coil. If the boiler pressure or temperature should change one tube is cut out, thereby causing the motor to operate at full speed until it reaches the desired position, when the tube is cut in again and the motor stops instantly under the plugging influence of the alternating current. As a result, changes in fuel and water can be made at full speed without danger of overtravel.

In the case of the air control, a variable inductance in the thyratron circuit causes the motor operating the dampers to rotate at high speed when the system is considerably out of balance, but reduces the speed as the desired position is approached, thus causing the system to come into balance slowly without overtravel or hunting. In the neutral position both tubes are cut out.

Penn Central Receivership Plea Dismissed by Court

Without leaving the bench Judge R. B. Gibson, presiding in U. S. District Court at Pittsburgh, Pa., late last week dismissed the plea for appointment of a temporary receiver for the Penn Central Light & Power Company (ELECTRICAL WORLD, August 13, page 193). The hearing was brief, and although Penn Central had witnesses present to testify and prove solvency, Judge Gibson did not hear any witnesses.

At the conclusion of argument by attorneys for the plaintiff and the company, the court announced that the petition was denied and that Penn Central's motion for dismissal of the entire proceedings would be taken under advisement. Judge Gibson indicated that he will investigate legal aspects of the case and determine whether the bill of complaint can be revised so that further recourse to the court will be available to the plaintiff. He made it clear, however, that the temporary receivership petition is definitely denied, indicating concurrence with the defendant's petition that Penn Central is completely solvent.

▼

Public Ownership Approved by Indiana Legislature

Bringing to a successful conclusion a long fight by the Municipal Rights League of Indiana for a law which would permit municipalities to purchase, construct and operate utilities without interference from the Public Service Commission of that state, the Legislature has passed Senate bill 417.

The bill passed the House by a 64 to 23 vote after a desperate attempt to amend was made by its opponents. Under it a city may condemn a privately owned utility for the purpose of its purchase and pay for the property through earnings.

Rates may be fixed by the City Council instead of the Public Service Commission and existing municipally owned properties are removed from the domination by the latter body.

If the City Council and utility officials are unable to agree on a purchase price the records are submitted to the Circuit Court, whose decision shall be final.

Although Governor Leslie has not expressed himself regarding public ownership, it is thought that he will sign the bill. It is said to be backed by 400 cities and towns in the state.

The bill provides that the municipality may issue securities bearing interest at 6 per cent to raise funds to pay for utilities and the seccurities become a lien only upon the utility property. It also provides that the municipality may hypothecate the earnings of the utility to pay for the construction or purchase of a utility property.

Representative Egan, on the final reading, declared the bill will not be constitutional. He also argued that municipal officers could reduce the rates below a minimum for political purposes and literally wreck the plants in order to win an election.

Valuations bill also passes

The amended House bill in the Indiana Legislature which provides that public utilities shall not have one valuation for taxation purposes and another for rate making has passed the Senate. Utilities shall be assessed for taxation at their true cash value as of March 1 each year. The bill provides that the valuation fixed by the Public Service Commission shall be the *prima facie* true cash value.

▼

No. Illinois Public Service Bonds on 6.99 Basis

The third offering of Insull company securities came on the market this week and was reported oversubscribed in short order.

Public Service Company of Northern Illinois first lien and refunding mortgage 6½ per cent five-year sinking fund convertible gold bonds, series G, were offered at 98 and accrued interest to yield about 6.99 per cent to maturity.

Commonwealth Edison and People's Gas Light & Coke issues were offered on 6 per cent and 6.24 per cent bases previously. ELECTRICAL WORLD, Aug. 13, page 194.

▼

Multiple Services for Washington, D. C.

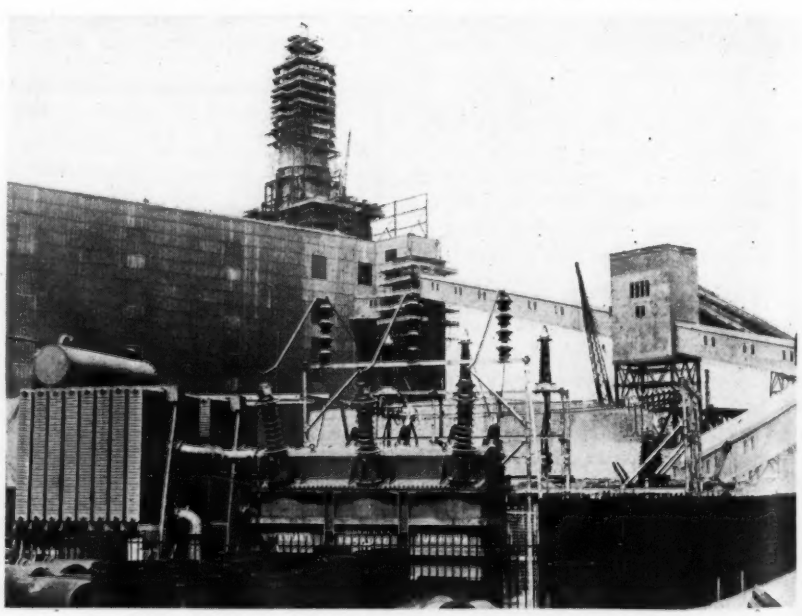
Three independent sources of electric power for Washington will be made available under plans now being carried forward by the Potomac Electric Power Company, according to C. Melvin Sharpe, executive assistant to the president of the company.

In connection with arrangements for the construction of the new $7,000,000 power plant at Buzzards Point, plans now are being formulated for provision of two new transformer stations, one at Takoma Park and another at Brightwood, to furnish additional sources of supply.

Washington's dependence on the bridge across the Anacostia River, which carries conduits bringing electricity from the main power plant of the company at Benning to the capital, played a large part in the decision to provide additional sources of local power. Recent plans to destroy the Benning Bridge so as to cut off the city's electricity were traced definitely to a group of "Reds" camped there at the time the bonus marchers were in Washington, according to Mr. Sharpe, and caused a realization of how "vulnerable" this one plant was from attack or accident, flood or wind storm.

▼

LONDON'S BATTERSEA STATION PROGRESSES



A recent view of London's $30,000,000 steam generating station at Battersea. The 132,000-volt, 60,000-kva. transformers shown are typical units for feeding to the grid scheme which interconnects England's electrical facilities. External oil-cooling units are used. The element shown under construction is one of the stacks.

Air-Conditioning Division Organized at Westinghouse

Formation of a complete organization for air-conditioning is announced by Westinghouse Electric & Manufacturing Company. Included in the company's study of all types of conditioning problems are reversed cycle refrigeration (ELECTRICAL WORLD, Aug. 6, 1932, page 169) cooling, humidifying, dehumidifying and air circulation and cleaning. Research in thermodynamics, ventilation, reverse refrigeration cycles, heating, practical design and factors that make for human comfort have evolved a line of apparatus said to meet the most exacting needs.

Unit installations for the home, office, barber shop, restaurant, hospital room, X-ray room, hotel room and small apartments are available. Also, railway installations for dining car, sleeping car, day coach and freight car cooling involving notable advances in practice (ELECTRICAL WORLD, July 9, 1932, page 39) have been designed.

J. W. Speer, formerly manager machinery electrification, has been appointed manager commercial air-conditioning products, in charge of the sale of commercial and railway air-conditioning apparatus. R. C. Cosgrove, manager refrigeration division, will head the domestic sales. W. C. Goodwin, supply engineering department, is in charge of the engineering and development.

▼

Associated Plea Denied by New York Commission

In announcing this week that the New York Public Service Commission had refused the petition of the twelve operating companies of the Associated Gas & Electric system for a rehearing of the recent proceedings which resulted in a commission order against "service contracts" and other practices under which it was claimed heavy and unnecessary charges were piled up against operating costs of the Associated subsidiaries, Chairman Milo R. Maltbie indicated that the commission would not only seek maintenance of its power in the courts, but would also ask for more stringent legislation next winter.

"The petition for rehearing," Mr. Mr. Maltbie declared, "is obviously only a preliminary step to an appeal to the courts. Such being the situation, the commission welcomes an opportunity to have the matter presented to the courts and a final determination made. If the Associated system can snap its fingers at the public and maintain that it is none of the commission's business whether 'siphoning' contracts are justified, the sooner the legal question is decided the better. If the legislation already in effect is defective the Legislature should be so advised. If the commission's position is correct, that should also be established."

▼

West Virginia Commission Balks at Legislative Order

In reply to a West Virginia House of Delegates resolution asking the Public Service Commission of that state to start downward revision of all public utility rates "in line with the reductions in general business and in conformity with the spirit of the times" the commission has issued a statement denying its authority to make arbitrary changes in rates.

"We do not understand," the commission reply stated, "that the House intended by this resolution to direct the commission to order a wholesale reduction in public utility rates, without regard to actual operating costs of each company whose rates are to be affected and without according such companies the right to be heard. Such action is beyond the delegated powers conferred upon the commission by the Legislature and beyond the powers that can lawfully be delegated to it.

"Whatever the notion of uninformed persons to the contrary, the fact remains that reductions aggregating $2,000,000 a year and affecting about 177,000 persons have been brought about in the past four years in proceedings initiated by the commission, without complaint from any ratepayer, and prosecuted by conference and negotiation in which the commission was full-handed with facts ascertained by its staff of experts."

▼

Angle of Suspension Used to Test Sag of Lines

Based upon the contention that to test the tension and sag of a wire span it is only necessary to determine the angle of suspension of the wire, a new type of clinometer with magnifying pointer has been developed and described by Seüchiro Noda of the Ryojun College of Engineering, Port Arthur, Manchuria.

It is pointed out that this method is most convenient since measurement of the angle is simple and can be accomplished without difficulty even when it is impossible in field work to measure the sag directly through lack of clear sight.

The new clinometer eliminates the difficulties inherent in older types when angles of about 5 deg. are encountered. The magnified scale for the newer instrument is obtained by an overbalanced pointer operating against spring action. The instrument, in use, is merely hung on the wires to be sagged, near the point of suspension, by means of hooks integral with the case. The magnification of angularity at 1 deg. is about 9.5 times; at 5 deg. six times.

Trade Revival Lags; Hopes High

HOPE STILL RUNS HIGH, as evidenced in security market and commodity prices, that the improvement, whether artificial or natural, in various underlying factors affecting the economic life of the nation, will lead to actual trade betterment before long. Foreign raids on our gold reserves have long since ceased; in fact, the movement of gold has been reversed. The ability of those seeking credit to obtain a hearing has been greatly aided by the credit expansion mechanisms recently instituted. Economically justified replacements and maintenance need not be deferred for lack of ability to finance.

On the other hand, there has not as yet been effected any results which point definitely to business revival. Steel activities are at less than 20 per cent of capacity. This week's figures for car loadings show a further decline to all but the lowest point for the depression. Energy production wabbles unsteadily at low levels. General business indexes continue to slump to new lows. Automobile production drops out of proportion to seasonal trends. Evidence is still lacking of any expansion in member bank credit to result from the improvement in sentiment in recent weeks.

▼

Water Heaters Rented to Maine Householders

Further to stimulate the use of electric water heating on its system the Central Maine Power Company recently inaugurated a rental plan which has added 150 heaters to its lines in about two months. The rental charge is $2 per month in addition to the electric service bill, and the yearly minimum guaranteed is $24. The heaters are 50-gal. units with copper tanks and are provided with 500-watt and 1,000-watt (1,500 watts total) elements.

It is estimated that on the $2 per month rental basis the installation will be paid for in about seven years by the customer. Service is furnished on a separate meter rate with a minimum charge of $4 per month and an energy rate of 1.5 cents per kilowatt-hour, or, if desired, on the single meter schedules of the company. The rental service has not been advertised in the newspapers, but has been brought to customers' attention by bill inserts. About 1,000 water-heating installations are now operating on the system.

Coming Meetings

Wisconsin Utilities Association—Commercial section, Eau Claire, Wis., Aug. 25-26. John N. Cadby, 135 W. Wells St., Milwaukee, Wis.

American Institute of Electrical Engineers—Pacific Coast convention, Vancouver, B. C., Aug. 30-Sept. 2. Middle Eastern District Meeting, Baltimore, Md. Oct. 10-13. H. M. Henline, 33 West 39th St., New York.

Great Lakes Division, N.E.L.A.—Engineering Section, Milwaukee, Wis., Sept. 6-8. General meeting French Lick Springs, Ind., Oct. 6-8. T. C. Polk, 20 N. Wacker Drive, Chicago.

Pennsylvania Electric Association—Bedford Springs, Pa., Sept. 7-9. H. A. Buch, Telegraph Bldg., Harrisburg.

Rocky Mountain Division, N.E.L.A.—Stanley Hotel, Estes Park, Colo., Sept. 12-14. G. E. Lewis, 367 Gas & Electric Bldg., Denver.

Empire State Gas and Electric Association—Saranac Inn, N. Y., Sept. 22 and 23. C. H. B. Chapin, Grand Central Terminal, New York.

Illuminating Engineering Society—New Ocean House, Swampscott, Mass., Sept. 26-30. E. H. Hobbie, 29 W. 39th St., New York.

National Electrical Wholesalers Association—Hotel Statler, Buffalo, N. Y., Sept. 26-30. E. Donald Tolles, 165 Broadway, New York.

American Welding Society—Buffalo, N. Y., Oct. 3-7. M. M. Kelly, 29 West 39th St., New York.

National Safety Council—Washington, D. C., Oct. 3-7. W. H. Cameron, 20 N. Wacker Drive, Chicago.

Association of Electragists International—Kansas City, Mo., Oct. 10-12. L. W. Davis, 420 Lexington Ave., New York.

▼

Interim Rate Reduction Secured in Wisconsin

As the result of negotiations instituted by the Public Service Commission about three months ago with the officials of the Madison Gas & Electric Company rates for electric and gas service will be reduced a total of $200,000 annually effective September 1. This means approximately 9½ per cent off from the gas and electric bills of Madison, Wis., consumers.

The reduced rates will remain effective pending completion of the formal case against the company which is now before the commission. It is expected that it will take between six and nine months before the formal case is completed. Costs of the investigation of the company's affairs by the commission will be paid by the utility as provided by a law passed by the 1931 Legislature.

The Madison Gas & Electric Company was commended by Commissioner David E. Lilienthal for its willingness to work with the commission during the negtiations.

"This negotiation has been marked by wide differences of opinion between the parties, but it has succeeded because both the company's executives and the commission conferees were honestly endeavoring to reach a settlement," Commissioner Lilienthal said. "The policy and practice of the company in dealing fairly and frankly with us throughout this protracted and trying negotiation seems to us not only commendable and public-spirited but in the long run shows good business judgment.

"The success of this negotiation makes it possible for the commission to secure for the consumers in Madison the benefits of lower rates without the delay of awaiting the completion of a rate proceeding, and yet without in any way compromising or affecting the outcome of the formal proceeding in which all the facts will be available for a formal determination."

▼

Public Utility District Voted by Oregon Citizens

By a vote of 1,035 to 782 the citizens of Tillamook County, Oregon, have committed that area to the formation of Oregon's first people's public utility district. Although two of the precincts within the district boundaries voted overwhelmingly against the proposition, the electorate of the county seat and two other precincts cast a majority vote. Upon receipt of the official returns of the election, the Hydro-Electric Commission will issue a proclamation to the effect that the district may proceed to establish and operate public utilities of all classes and also acquire by condemnation or outright purchase the properties of any or all private utilities now located within the district.

Among the private utility properties now situated in the district are those belonging to and operated by the Mountain States Power Company. They consist of a steam-generating plant in the city of Tillamook, transmission line with hook-up with the company's Albany-Dallas main line, and a distribution system which serves territory of considerable extent outside of the established district.

The Oregon practice of creating utility districts came into existence through the adoption of a constitutional amendment, and the 1931 state Legislature enacted laws providing for procedure in connection with the formation and organization of such districts.

▼

Tax Absorption in Wisconsin

The Wisconsin Public Service Commission is reported to have prepared instructions for private and public utilities in the state indicating a method by which they may legally absorb the 3 per cent gross revenue tax on electricity furnished consumers, and to advocate adoption of the plan in order to prevent discrimination in net charge to consumers. The commission announces that utilities at Manitowoc, Menasha, Wisconsin Rapids and Waterloo, Wis., all of them municipal utilities, have already adopted the plan devised by the commission and their actions approved by the state commission.

City Charges Interference; Ohio Utility Sued

Piqua, Ohio, voted a bond issue of $800,000 for the construction of a municipal light plant, but no bids were received for the $480,000 of securities offered. Last week the Piqua City Commission obtained a temporary restraining order against "further interference" through a petition naming the Dayton Power & Light Company and others. It is alleged that the power company has no franchise to sell current and that its alleged perpetual franchise is spurious. This has been interpreted as a Council move to attempt to eject the company from the city.

The temporary restraining order stops defendants, including individuals, from circulating initiative petitions by which they seek to delay the construction of the plant until 1935 and from asking for a referendum on a recent bond ordinance.

They also are restrained from meddling with the sale of city securities to be issued for providing funds so contracts may be made with bidders who have offered to perform labor for about $400,000, a 25 per cent saving under the estimated cost.

The defendants are charged with having induced the Ohio Teachers' Retirement Fund trustees to repudiate a contract with the City Commission to take city securities after $25,000 had been advanced. It also is charged the power company and others had impaired the city's credit and interfered with the sale of bonds advertised for sale August 10.

The City Commission declares three courts have found the city has the right to proceed with building the plant as voted.

▼

Accident Prevention Work Decentralized in Alabama

In order that every accident may be promptly investigated, responsibility fixed and disciplinary action taken when necessary, the Alabama Power Company has decentralized its accident prevention work and set up new committees in each division for that purpose. Heretofore every accident has been investigated by the general safety committee. All acts of the divisional committees are subject to review by the headquarters committee.

Stipulation is made that where the situation calls for it, a foreman may be disciplined for the action of his men. Where an accident has occurred in which some safety rule has been violated it is pointed out that disciplinary steps are for violation of the rule and not for the accident. The new set-up was promulgated by J. M. Barry, vice-president in charge of operations.

Metropolitan Edison Denies Commission Jurisdiction

The Metropolitan Edison Company has filed with the Pennsylvania Public Service Commission a motion to dismiss the petition of three minority stockholders of the company for an investigation of the relations between that utility and the Associated Gas & Electric Company.

It was asserted in the petition that the Associated Gas & Electric Company is requesting such profitable operating companies as the Metropolitan Edison to make up losses sustained by other units of the Associated system.

The motion to dismiss declares that the commission is without jurisdiction to deal with the complaint, and that the commission "does not have the power or authority to substitute itself for the board of directors of the respondent in the direction and management of its business or investment of its moneys."

It is further contended that the commission "has no jurisdiction to investigate the corporate structure of the Associated Gas & Electric System or respondent's relation thereto and to other persons controlling the same, or such persons' influence or control of respondent."

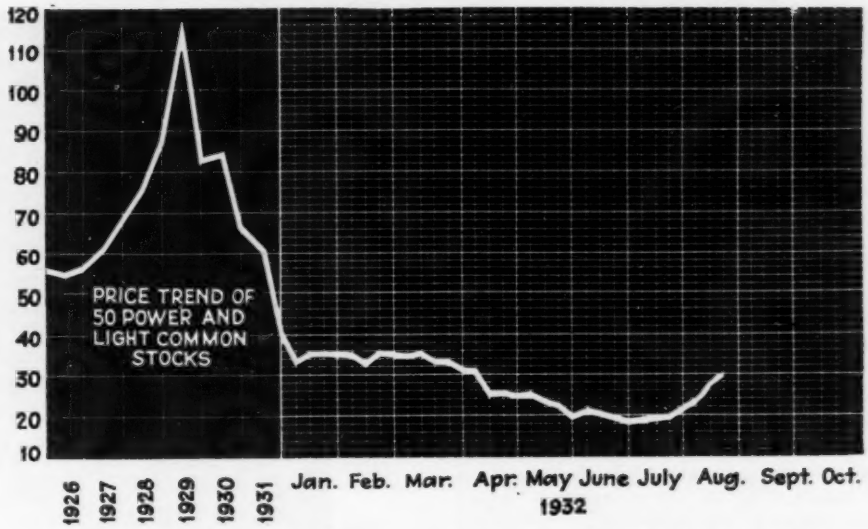
▼

June Output Down 13 per Cent

As was foreshadowed in the weekly estimates announced by the National Electric Light Association, energy production during June was 13 per cent less this year than last. Figures recently released by the U. S. Geological Survey give the total for all public utility plants as 6,536,893,000 kw.-hr., against 6,630,367,000 kw.-hr. in May and 6,778,652,000 kw.-hr. in April. The Survey's report includes electric railway plants and others contributing to the public supply of energy, as well as central stations for light and power.

The average daily output was about 2 per cent greater in June than in May, the change being very slightly better than the normal from May to June based on twelve years of records.

Stock Prices Continue Upward



In spite of a fairly rigorous reaction last Saturday the stock market continued on its upward trend with the resumption of trading this week. "Electrical World" average of 50 power and light stocks stands at 29.3. Utility securities showed slightly greater strength than the balance of the list.

▼

The output from water power continues relatively larger than in corresponding months of 1931, the percentages compared with total output being as follows:

Month	1931	1932
January	30	41
February	30	42
March	34	42
April	41	46
May	41	45
June	38	41

Regionally the greatest decrease in total production from that of 1931 occurred in the Mountain Division, apparently as a result of conditions in the metal mining industry, as is apparent from the following table giving the decrease, in per cent, for May and June.

Division	May	June
New England	18	17
Middle Atlantic	10	8
East North Central	15	14
West North Central	8	3
South Atlantic	15	18
East South Central	15	22
West South Central	12	5
Mountain	28	32
Pacific	10	11
United States	13	13

▼

Delinquent Electrical Accounts

(National Electrical Credit Association)

Number of Accounts Reported

Division	July 1931	July 1932	Per Cent Inc. or Dec.	Seven Months 1931	Seven Months 1932	Per Cent Inc. or Dec.
New York	221	239	+ 8.1	1,840	1,688	— 8.3
Middle and Southern Atlantic	110	143	+50.0	876	797	— 9.0
New England	101	84	—16.8	663	761	+14.8
Central	501	372	—25.7	4,166	3,363	—19.3
Total	933	838	—10.2	7,545	6,609	—12.4

Total Amounts Reported

New York	$32,777	$14,511	—55.7	$242,780	$152,634	—37.1
Middle and Southern Atlantic	9,264	9,506	+ 2.6	111,684	72,797	—34.8
New England	8,749	8,009	— 8.5	59,537	57,842	— 2.8
Central	47,832	24,056	—49.7	383,430	250,257	—34.7
Total	$98,622	$56,082	—43.1	$797,431	$533,530	—33.1

Power Commission Report to Show Corporate Groups

An analysis of some of the intricate corporate relationships of holding and operating companies in the electric utility field is promised by the Federal Power Commission, which on August 13 issued the following statement: "The forthcoming report of the Federal Power Commission on holding companies will contain statistical analyses of 43 operating companies holding 48 major project licenses. These 43 companies are subject to control in more or less complicated systems leading up to ten top companies.

"The whole set-up is that of ten large groups, within each of which a relatively small number of operating companies —on the average about one in eight— are licensees of the Federal Power Commission. In the case of the United Gas Improvement group only six out of 79 companies submit reports to the Federal Power Commission, but in that of the Pacific Gas & Electric Company the ratio is larger, six out of thirteen.

"In the charts in this report, which show the exceedingly complex relationships between top companies which control and operating companies which produce, all of the 595 companies are not public utilities. Yet all of them are necessarily included in order to exhibit in true proportions the far-flung control which, through the process of holding company finance, may be exercised by a single company at the top. In no other way can these financial pyramids be adequately pictured. The Napoleons of

Finance may well gaze in wonder at these modern pyramids which they themselves have built."

▼

Sliding Scale Return Attracts Investors

British investors who find themselves with surplus funds as a result of the War Loan conversion scheme are buying heavily of London electricity supply stocks. The undertakings which operate under the 1925 act have special characteristics which give the shares an added attraction.

Under the act the dividends these companies are allowed to pay are restricted, from this year, to 7 per cent per annum on the ordinary capital, subject to a sliding scale clause. This provides that if the average charged consumers is less than "standard" prices which are fixed by authority, then, if there are sufficient profits available, the company is entitled to retain for the benefit of the ordinary stockholders a sum not exceeding one-sixth of the difference between the "standard" prices and the actual prices charged. This is called "ordinary shareholders' benefit under the sliding scale," and can be distributed in the form of additional dividend.

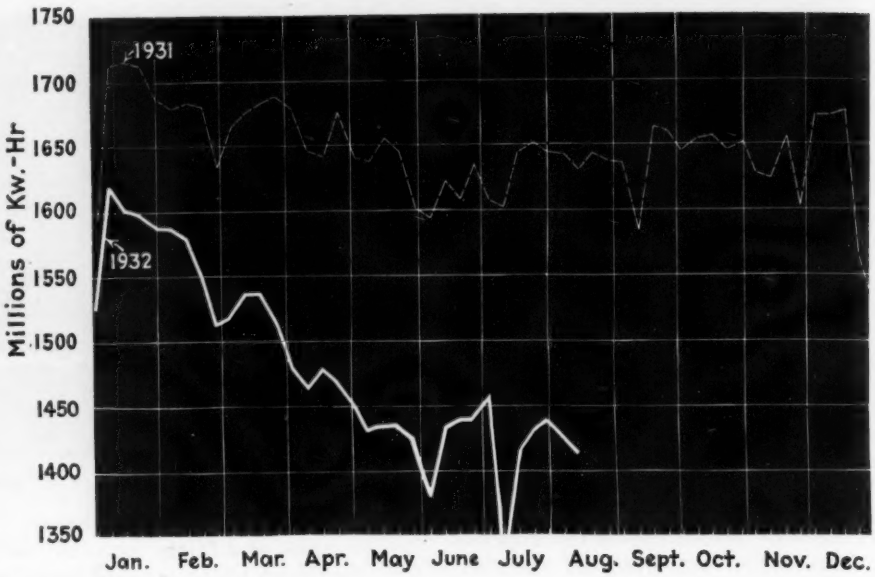
The effect of these arrangements is virtually to make the 7 per cent dividend rate now fixed a minimum, leaving the possibility that increases may be made in future years provided that the companies are able to give efficient service on economical terms.

Among the undertakings operating under the 1925 act are the Charing Cross Electric, Westminster, St. James' and Pall Mall, South London, Brompton and Kensington. The yield now offered on these companies' ordinary shares is 4⅓ per cent, the shares being obtainable around 32s. ($8), against 30s. ($7.50) prior to the announcement of the Government's War Loan conversion plan.

A point attracting considerable attention is that under the provisions of the act the undertakings are to be taken over at par by the London & Home Counties Joint Electricity Authority in 1971. Purchasers of the ordinary stock at today's price are therefore inviting a loss on repayment in 1971 of 12s. ($3) per share or at the rate of 1½ per cent per annum, bringing the redemption yield down to £2 17s. 6d. ($14.35).

Against this, however, may be set the

Energy Output Falls Slightly



WEEKLY output of electrical energy continues to run virtually parallel with last year's production for corresponding periods and to show comparatively small changes from one announcement to the next. For the week ended August 13 it amounted to 1,415,122,000 kw.-hr., 1 per cent less than in the preceding week and about the same as in the middle of July. A similar decrease occurred last year; result—the output remains 13.1 per cent under that of 1931.

These moderate fluctuations are probably not very significant, though evidently no appreciable upward trend has yet set in. A slight relative gain is indicated in the West, a loss smaller, in the East, with no change in the Central area.

Weekly Output, Millions of Kw.-Hr.

Week Ended	1932	1931	1930	1929
August 13	1,415	1,629	1,677	1,733
August 6	1,427	1,643	1,692	1,730
July 30	1,440	1,644	1,678	1,725
July 23	1,434	1,651	1,686	1,723
July 16	1,416	1,645	1,667	1,727

Per Cent Change from 1931

Region	Week Ended Aug. 13	Aug. 6	July 30
Atlantic Seaboard	—10.1	— 9.0	— 9.0
New England alone	—11.2	—10.0	— 9.5
Central industrial	—16.6	—16.6	—15.1
Pacific Coast	—11.9	—13.0	—14.7
United States	—13.1	—13.1	—12.4

▼ ▼ ▼

Current Earnings Reports of Electric Light and Power Companies

OPERATING COMPANIES

	1932	1931	Per Cent Increase	Operating Ratio 1932	Operating Ratio 1931
Puget Sound Power & Light (Year ended May 31)					
Gross earnings	14,918,958	16,594,739	—10.1	61	63
Net earnings	5,789,532	6,130,840	— 5.6	..	..
Net profit	751,372	773,924	— 2.9	..	..
Southern California Edison* (Year ended June 30)					
Gross earnings	39,232,925	41,411,589	— 5.0	32	32
Net earnings	26,899,417	28,380,504	— 5.0	..	
Net profit†	19,971,857	21,373,682	— 7.0	..	..
Tennessee Electric Power (Year ended May 31)					
Gross earnings	13,051,555	14,110,278	— 7.5	58	61
Net earnings	5,481,902	5,455,504	0.5	..	..
Net profit	1,439,643	1,810,617	—20.4	..	..
Virginia Electric & Power (Year ended May 31)					
Gross earnings	16,452,147	17,064,648	— 3.6	65	67
Net earnings	5,625,381	5,628,571	— 0.0	..	..
Net profit	2,605,343	2,740,533	— 5.0	..	..

*Operating expenses do not include depreciation.
†Balance available for preferred and common dividends.

HOLDING COMPANIES

	1932	1931	Per Cent Increase	Operating Ratio 1932	Operating Ratio 1931
Nevada-California Electric & subs. (Year ended June 30)					
Gross earnings	5,352,849	5,795,497	— 7.7	60	60
Net earnings	2,146,728	2,290,224	— 6.2	..	..
Net profit†	675,693	835,501	—19.1	..	..
North American & subs. (Year ended June 30)					
Gross earnings	112,595,410	121,827,955	— 7.6	65	64
Net earnings	39,597,926	43,689,672	— 9.3	..	..
Net profit	19,557,331	24,365,006	—19.8	..	..
Public Service of New Jersey & subs. (Year ended June 30)					
Gross earnings	132,206,560	139,272,569	— 5.1	66	68
Net earnings	44,467,948	45,019,200	— 1.2	..	..
Net profit†	30,149,237	31,267,816	— 3.6	..	..

Gross earnings — Gross operating revenue. Net earnings — Earnings after deduction from gross earnings of operating expenses taken to include taxes, depreciation, maintenance, operating, etc. Net profit — Balance available from income for common stock dividends.

probability that the dividend rates of the companies will be stepped up under the sliding scale clause over the next 39 years. It is generally estimated that in this way the redemption loss will be more than made good.

▼

Georgia Power Fights Vandalism with Rewards

Large notices in Georgia newspapers inform the public that the Georgia Power Company is doing its best to fight the actions of a small group of vandals who, it is understood, are being urged to "go out and tear down as much of the Georgia Power Company's property as you can." A $2,500 reward is offered for information leading to the arrest and conviction of any person or persons guilty of acts of vandalism against the company's property.

Pointing out the difficulties of patrolling a system of transmission lines extending over 40,000 square miles the company solicits the co-operation of the public.

One advertisement states in part:

Acts of vandalism are still being perpetrated against this company's property. On Tuesday night, August 9, an attempt was made to cut off completely Atlanta's electric power supply. Steel transmission towers were dynamited near Fairburn and Norcross. Failure of a charge of 25 sticks of dynamite to explode after it had been placed against another steel tower at Bremen prevented interruption of service to the territory served by that circuit. Threats are being made of further violence—dynamiting and other malicious damage to power plants, substations, electric lines, towers and other facilities of this company similar to the acts of vandalism which have been perpetrated sporadically ever since a few of this company's electrical workers went out on strike in March, 1931.

Acts of vandalism against the property of this company not only are harmful to this company, but also are dangerous to the public. A high-tension electric line, pulled down in the dark of night in an act of vandalism, might injure or destroy property and human life before the trouble could be located and remedied.

▼

High-Speed Loading of Cars for "Seatrains"

Whole trains of freight cars will be transported by ship between New York harbor and Havana when the new route of Seatrain Lines, Inc., is put in operation some time this fall.

Electric hoists will pick up the loaded freight cars bodily and swing them from dock to ship, or *vice versa*. When two-way handling is in operation the complete cycle can be accomplished in five minutes. Cars weighing up to approximately 100 tons can be accommodated, although the average weight of a loaded car is 55 tons. The ship will have a capacity of somewhat more than one hundred cars, which is equivalent to two freight trains of normal length.

The two electric motors for operating the hoists, which will be installed by General Electric, are rated at 250 hp., and in addition there is to be a 100-hp. motor for handling the bridge motion. When lowering loads the motors are so designed that regenerative braking is applied during the early part of the descent and dynamic braking during the final stage. This permits the loaded car to be lowered gradually and finally deposited so gently as not to injure its contents. In case of emergency there is provision for operating with only one motor, thus avoiding delays in loading or unloading.

▼

Seattle to Ask R. F. C. for Construction Funds

Following an informal petition to directors of the Reconstruction Finance Corporation by Superintendent J. D. Ross of Seattle's City Light Department (ELECTRICAL WORLD, July 23, 1932, page 104) a formal application for a loan of $7,500,000 will be made shortly.

The projects to be financed under the proposed loan are: Completion of the 190,000-hp. Diablo plant of the Skagit River power development, $2,495,000; completion of a double-circuit, 240,000-volt power line 120 miles long from Gorge Creek at the Skagit to the south substation in Seattle, $2,804,000; additions to the south receiving station at Fourth Avenue South and Spokane Street, $500,000; addition of two stories to the City Light office and substation building at Third Avenue and Madison Street, $493,000; purchase of the remaining street railway substation, as per contract with the Puget Sound Power & Light Company, and the necessary machinery to make completed system, $394,000; extensions of the Seattle distribution system, $1,000,000.

The principal reasons for asking the loan at this time, the application states, are to relieve the unemployment situation in Seattle as far as possibe; to have the new Diablo plant completed in the next two years, when the additional power will be badly needed, and to secure the reduction in fuel oil expense that the additional hydro-electric production would provide. The application points out that City Light is entirely self-liquidating and "eminently able to liquidate the loan asked as it falls due."

▼

Mercury Boiler Economies

Hartford Electric Light Company reports an economy during the first six months of 1932 that saved the company $110,000 through the use of mercury boilers with oil for fuel.

Major New Construction This Week

INDUSTRIAL drives, heavy-duty motors and controls, regulators, switchboard apparatus, etc., will be installed by Columbia Steel Corporation, Torrance, Calif. A $400,000 project.

A $150,000 fund has been authorized at Morris, Minn., for a city-owned electric light and power plant.

Transformers and transformer room equipment, heavy-duty motors and controls, elevating and conveying machinery, etc., required for development of Cedar Mountain Coal Company, Seattle, Wash., in Whatcom County fields. Total cost over $750,000.

Bids asked until September 13 by Construction Service, Veterans' Administration, Washington, D. C., for electric installation in new institution buildings at Fort Lyon, Colo., including outside distribution system, elevators, refrigerating plant and ventilating equipment.

Machine drives, motors and controls, regulating equipment, conveyors needed for two additions to paper mill of Berst-Forster-Dixfield Company at Plattsburg, N. Y. Estimated to cost about $200,000.

A 13-mile power transmission line is planned by St. Joseph Railway, Light, Heat & Power Company, St. Joseph, Mo., from Gower, Mo., to point in Clay County, with substation facilities at latter place. Cost about $27,000.

Motors and controls, regulators, switchboard equipment, conveyors, will be installed in $250,000 addition to cereal products plant of W. K. Kellogg Company, Battle Creek, Mich.

Bids for a quantity of wire, in lots of 500,000 to 1,500,000 ft., will be received until August 26 by Signal Supply Officer, Army Base, Brooklyn, N. Y. (Proposal 5).

New Utility for Ohio

Great Lakes Utilities Company has been organized at Toledo, Ohio, and has filed application with the Ohio Public Utilities Commission to serve the public generally as a public utility. The authority was granted, upon the usual condition that proceeds are to be held in escrow pending further order of the commission. The company's charter authorizes it to produce, buy, sell and distribute electric current, water, natural or artificial gas. It is the avowed "intention of the company to negotiate for acquisition of municipal electric light and power plants and franchises.

▼

New York Metal Prices

	Aug. 9, 1932 Cents per Pound	Aug. 16, 1932 Cents per Pound
Copper, electrolytic	5.375	5.375
Lead, Am. S. & R. price	3.10	3.20
Antimony	5.00	5.00
Nickel ingot	35.00	35.00
Zinc, spot	3.10	3.10
Tin, Straits	22.50	23.20
Aluminum, 99 per cent	23.30	23.30

Ritchie Out of Baltimore Dispute

Governor Ritchie of Maryland has refused to interfere with the Public Service Commission in its action upon a resolution of the City Council of Baltimore calling for a reduction of public utility rates to a parity with "the existing prices of other commodities and services." The Governor contends that the commission and people's counsel are following the situation closely. "The law," he pointed out, "gives no authority at all to the Governor in the matter."

▼

Electrical Goods Orders Drop

New orders booked during second quarter of this year by 84 manufacturers of electrical goods were $98,079,886, against $99,351,480 for first quarter of 1932 and $224,347,794 for second quarter of 1931, according to the United States Bureau of the Census.

▼

Emergency Lighting Code Asked

National Electrical Manufacturers' Association has requested the American Standards Association to initiate a project on emergency lighting. N.E.M.A. points out that many state and municipal regulatory bodies have developed regulations requiring the installation of emergency lighting systems and that requirements in these regulations make it difficult for manufacturers to develop a product acceptable to the various groups. The request has been referred to the safety code correlating committee and the electrical standards committee.

▼

Dallas Accepts Rate Cuts

Acting upon the advice of engineers employed by the city to check data affecting the rate controversy with the Dallas Power & Light Company (ELECTRICAL WORLD, August 13, 1932, page 196) the City Council last week accepted the rate reduction offered to it by the utility.

▼

Canadian Research Laboratories

Officially opened on August 10, the recently completed National Research Laboratories building in Ottawa is well equipped. It consists of a main building, power house and small laboratories. A high-tension laboratory is provided where researches will be carried on at voltages up to 750,000.

▼

Thomasville, Ga., Fights Tax

Regardless of the recent government ruling that municipally owned power plants must collect the 3 per cent tax from the consumers, the Thomasville Light & Water plant has reaffirmed its decision to absorb this tax for its consumers. Receipts for bills rendered customers will, it is stated, be stamped "includes federal tax." The city will then pay the government the amount due as tax on these bills. Should the government insist that the tax be collected from consumers, the city will collect as required, and then repay to its customers the exact amount of the tax collected.

▼

I have repeatedly recommended the federal regulation of interstate power. I shall persist in that. I have opposed the federal government undertaking the operation of the power business and I shall continue in that opposition.

I have for years supported the conservation of national resources. I have made frequent recommendations to the Congress in respect thereto, including legislation to correct the waste and destruction of these resources through the present interpretations of the anti-trust laws, and I shall continue to urge such action.

[PRESIDENT HOOVER accepts the nomination]

▼

General Gas Fights Receivership

Alleging that the suit filed in Chancery Court, Wilmington, Del., by General Utilities and Frank R. Kent, asking that receivers be appointed for the General Gas & Electric Company, was not filed in good faith, but was filed by complainants for the purpose of harassing and annoying it, and in pursuance of a scheme to compel purchase of their stock, General Gas & Electric has filed its answer. It is further declared that consummation of exchange offers will result in great benefit to the corporation through the elimination of outstanding debts to mature in the immediate future.

▼

Iowa Electric to Reduce Debt

A new financing program undertaken by the Iowa Electric Light & Power Company involves the sale at par value of a $6,000,000 issue of first mortgage ten-year 7 per cent gold bonds, series C. The company has agreed to a program of debt retirement and at the expiration of three years the present debt will have been cut 14 per cent.

▼

Highway Lighting Rates Cut

Citizens of 83 North Carolina communities are to benefit by reduced rates for street lighting announced by the Carolina Power & Light Company through the state Corporation Commission. Action of the company in reducing its street lighting rates came close on the heels of the commission's order to all electric, gas and telephone utilties operating in this state to arrange conferences with it looking to reductions in rates.

Municipal Plant Can Aid Trolley

City Attorney A. M. Aiken of Danville, Va., in a letter to the Danville City Council has ruled that, in his opinion, it is legal for the Council to grant a preferential power rate to the Danville Traction & Power Company, which operates the Danville street car system and which faces dissolution in October unless new economies to reduce operating expenses to meet lagging patronage can be met. Council members had believed that they could not legally reduce power rates to any one concern, but the city attorney holds that this can be done, provided such a contract would not result in a loss to the city.

▼

Defiance Against Prorating

Defiance, Ohio, has become involved in an altercation with the Toledo Edison Company over rates for electricity and gas and has secured a temporary injunction against the company to prevent collection of prorated bills for 38 days instead of the usual 30 days. The prorating was involved in an effort to change the meter-reading dates. Petitions then appeared in circulation asking City Council to seek rate reductions and, if refused, to start plans for a municipal plant.

▼

Powercraft Takes Sessions Patents

The Powercraft Corporation has been formed with headquarters at St. Louis, Mo., and has acquired the Electrical Fittings & Equipment Company of Detroit. E. O. Sessions has been retained as engineering counsel and the company will manufacture under his patents a complete line of disconnecting switches, busbar supports, cable heads and bells, high- and low-tension equipment.

▼

Seven Miles of Welding

When the new airship hangar at Sunnyvale, Calif., is completed more than 7 miles of welding will have gone into its construction. This structure, which is to house the new U. S. Navy dirigible *Macon*, will be approximately 1,200 ft. in length by 308 ft. in width by 225 ft. in height. The floors consist of 2x12-ft. steel plates $\frac{3}{8}$ in. thick, welded together. The splices between the ends of the plates are welded butt-strap joints, as are the longitudinal joints, except that in the latter case the top flange of supporting 3-in. I-beams serve as the strap. The 3-in. I-beams are in turn welded to 20-in. I-beams. All the welds of the floor plates are continuous and the floor plate welds are ground flush with the top surface after the welds are completed. The welding work is being done with General Electric equipment.

Sealed Transformers Offered in England

Hermetically sealed transformers which eliminate contact between insulating oil and atmosphere, wastage of oil, maintenance of the dielectric and breathing of the apparatus are appearing in British practice.

The first offering by the British Electric Transformer Company involves a flat round oil container attached at its center to the transformer tank lid, so that its interior communicates with the main tanks and is completely filled with oil. The container is constructed of two corrugated copper disks, joined together on their outside edges by a solid band one inch wide and left free to expand outward from each other in the center. The plane of the disks is always horizontal, so that the fluid pressure inside is equal at any point of the periphery. Three lugs on the periphery of the disks are drilled to slide freely over three steel standards fitted to the tank lid, which act as guides to the disk as it rises and falls according to the temperature.

The diameter of the disks is so arranged that for a 50 deg. C. rise in tank temperature the back pressure from the flexible diaphragms when expanded does not in any case exceed 2 lb. per square inch. The temperature rise in the expansion device is never so great as in the transformer tank itself, the figure usually reached being about two-thirds of the tank temperature owing to the greater proportion of cooling surface exposed by the disks.

The apparatus is said to be applicable to any small or medium-sized unit whose design permits of its complete sealing at the factory.

Special arrangements have also been made by the company for filling and sealing these transformers, so that at ordinary temperatures the tank is under a slight vacuum of about ¼ lb. per square inch. This is found to be an advantage, since it reduces the back pressure reached at higher temperatures by a corresponding amount.

▼

Sodium Vapor Lamp Under Development Here

Progress in the development of the sodium vapor lamp in this country is reported by lighting engineers of the General Electric Company, who have been working on the problem at the Schenectady research laboratory and in the company's lamp development laboratory at Nela Park, in Cleveland. They have found the sodium vapor lamp to be a desirable light source where monochromatic radiation is required, in spectacular lighting and in the immensely wider field where cheap light is demanded, according to a recent announcement. The new lamp is not appropriate for general lighting in houses or stores where color values are essential.

In Schenectady a practical 100-watt, direct-current lamp giving an over-all efficiency of 34 lumens per watt is reported to have been constructed. This can be increased by known means to 50 lumens per watt. The ordinary 100-watt lamp operates at only 14 lumens per watt, and the largest and most efficient of the incandescent lamps, intended for operation at 1,000-hour life, has an efficiency of but 22 lumens per watt.

The tubular lamp developed in Schenectady operates within an inclosing glass cylinder to conserve the heat. The outer cylinder is evacuated by sealing the inner tube and treating the outer one as a vacuum lamp. The tube operates at about 410 deg. F. (at an efficiency of 70 lumens per watt when measured on the glow alone) and with a brightness of 14 cp. per square centimeter. This brightness is greater than can be obtained with neon or any other glow tube. Neon and mercury tubes of similar construction have a glow efficiency of only 15 to 25 lumens per watt.

Difficulties in the operation of sodium lamps lie in the attack of hot sodium vapor upon glass, which produces serious discoloration and absorption of light, and in the necessity of operating at temperatures of from 400 to 650 deg. F. Only in this range does sodium, a solid at room temperature, acquire sufficient vapor pressure to develop bright luminescence. Both of these difficulties are now being overcome, promising practical success for the lamp, the report states.

The glass technology laboratory of the lamp department in Cleveland has developed and is now making a glass having great resistance to the attack of sodium. This glass is now being used in a small, efficient, self-starting lamp which has been developed at Nela Park.

▼

Gaseous Discharge Lamps Light Streets in Holland

Following a year of experimental street lighting using a new type of gaseous discharge lamp a mile of the main road between Maastricht and Nijmegen, Holland, has been provided with such sources. Lamps are placed at a height of 26 ft. at intervals of 83 ft. According to *Electronics* this installation was opened to traffic on July 1, 1932, and "so intense is the illumination along this roadway that, driving a car at 50 or 60 miles per hour without headlights, one feels perfectly safe." The lamps are so placed in the reflectors that no direct light strikes the eye.

In the new lamp, developed by Dr. Giles Holst in the laboratories of the Philips Glowlamp Works, a low-voltage discharge takes place in a mixture of neon gas and sodium vapor, between an oxide cathode and one or more anodes. The lamps used in the highway lighting installation require an input of 100 watts to give from 500 to 600 international candles. The total flux of light amounts to between 5,000 and 6,000 lumens. The surface light intensity is about 7 international candlepower per square centimeter.

In order to secure sufficient sodium vapor pressure the bulb must have a temperature between 200 and 300 deg. C. For this reason the lamp has been inclosed in a vacuum jacket tube or glass container. The lamp resembles to some extent both the well-known gas-filled rectifier tubes and the sunlight lamp.

The light emission is mostly due to the sodium vapor; the color of the light therefore approaches that of the yellow sodium spectrum lines. The arc potential is about 12 volts and the anode current about 5 amp. As the light is almost monochromatic it can only be used for special purposes; the unusually large visual acuity which is secured by it when used for road or street lighting, however, is said to be extraordinary.

EDITORIALS

L.W.W.MORROW
Editor

Recovery now up to business

THE administration program for business recovery has reached the stage that calls for the exercise of initiative and courage by private business. Washington believes that the powerful but orthodox remedies it has applied have reacted to make it possible for business to go forward. This is the reason for the conferences with business leaders now planned and for the organization of regional and national committees to stimulate industry.

The administration's program has been consistent and effective so far. First it strengthened the banking situation and met the gold export attack with success; then it strengthened the commodity and security markets, and now it says that private business should go forward and use the credit available. The security market recovery is not a flash in the pan, but represents a large influx of foreign investment money and of money from domestic investors. There is an investment and not a speculative basis for present market values.

Utilities have welcomed the new credit situation for it has made possible large refunding operations and opened the way to business expansion. They should now take an aggressive attitude on sales and on maintenance and modernization of properties. They know that every market for service is unsaturated and they know that maintenance and modernization have lagged during the past three years. Sales efforts of electrical manufacturers also should be tied into this program effectively. If the administration has had the courage to make such a successful and even spectacular defense of the dollar, surely private business can appreciate the sound credit background that now exists and will respond to the need for it to show courage and aggressiveness in order to expedite the return of normal conditions.

Power not in politics

PARTY platforms and acceptance speeches of the presidential candidates have been completed and the political campaign is under way. Both parties urge federal regulation of interstate electric power, both parties advocate private ownership and operation under regulation, both parties minimize the importance of the power issue and stress prohibition, unemployment and measures for economic recovery. President Hoover advocates the St. Lawrence project as an aid to commerce and navigation, but Governor Roosevelt goes further and advocates state-owned developments, such as the St. Lawrence, in order to introduce a threat of state ownership of all utilities and to secure a contractual control of rates established by purchasers of power from the state-owned plants. His advisers are chiefly either ardent advocates of state ownership and operation of utilities or others well known for their extreme attitude toward the utilities.

On the whole, however, the official platforms and the statement of the candidates of both parties offer no threats to the power industry. They admit, by inference at least, that power is not a political issue of even minor importance. Thus the election of either candidate should and will depend upon his respective policies with regard to social and economic problems that hang over the

country and handicap the return of normal conditions. Utility executives can continue industry expansion and investors in industry securities can retain their holdings with full assurance that the political horizon is clear.

This matter of dealer financing

GROWTH of residence load waits today on appliance selling and appliance selling hangs in the balance. Qualms of public policy and political fears have greatly unsettled the power companies in the last year in their merchandising plans. As a result the flow of labor-saving and comfort appliances into the homes of America has slackened. The dealer becomes steadily more important in the picture and the weakness of the dealer is a problem that concerns the entire industry.

The crux of it all is installment financing. The public has learned to buy that way and likes it. The dealer lacks capital to carry term-payment contracts. The large acceptance corporations won't bother with small paper. The power company, though ideally equipped to bill and collect, is afraid to finance the dealer because both the banker and the commissions frown on it. What to do?

After all, this is a community consideration. It has to do with living conditions in the town. The real estate men, the building and loan associations and the mortgage bankers are concerned no less than the power company and the electrical dealers, wholesalers and manufacturers. The need is to provide the people of that locality with a financing service that will enable them to equip their homes with the modern devices that contribute to the enjoyment of life. The best way would be for these several interests to co-operate in the establishment of a local acceptance corporation, in which they all participate. This local finance company to discount local small paper and rediscount with one of the large national credit companies.

Such an arrangement would put the operation on a banking basis, with each interest represented in the management. It would lift the whole matter of installment financing out of controversy within the industry.

Price and profit no part of rate regulation

PEOPLE sometimes wonder why utility regulation presents such a muddled appearance. Possibly the explanation rests in the three fairly distinct factors that confront the commissioners in their deliberations. The laws under which they function take cognizance of only one of these factors—regulating rates to provide a fair return on the money hazarded in the business. Public opinion, just as potent an influence as the law, forces attention on the two other factors—price for the service and the profits that it establishes for the most hazardous investment, the common stock.

Regulation of rates by law is confined to a single index of return, that upon the over-all fair value of the property, and this is reflected in the interest and dividends in the sum total of investment by way of bonds, debentures, preferred and common stock. The law takes only secondary notice of the specific return to each type of investor. But the invasion of the holding company forced pyramided return upon common stocks into a predominant position. That accounts for the disposition of commissions to regulate profits to the point where they appear almost to forget about regulating rates.

Lately a new element has attracted notice, and that is price for service, especially in relation to the consumer's capacity to pay. More important even in the immediate future is the shaping of the price to a curve that will bring both users and utilities the greatest opportunity to derive benefits from orderly expansion of electrical usage.

These two latter influences, not contemplated in the statutes, are what have caused regulation to reach for control beyond the letter of the law. They will stay in the picture, but to an extent that can be controlled by the industry in such a way that concern about them by commissions can be minimized. Simplification of financial structures to remove emphasis on returns to holding company securities takes care of one. Intelligent realignment of rate structures to bring tapering block rates into accord with the public will to spend will take care of the other. In that way regulation can be reverted to its fundamental legal concept of a fair over-all return on an equitable value of the enterprise.

"See"-Levels in Lighting

By M. LUCKIESH
Director Lighting Research Laboratory, General Electric Company

New knowledge creates a new viewpoint and a new era in lighting. Humanitarian foot-candles add to efficiency foot-candles

Fig. 1—Fairly satisfactory from the engineering viewpoint, but inadequate and even primitive from the new viewpoint of the science of seeing

THERE is no depression in artificial lighting. Measured in lumen-hours, lighting has scarcely been affected, while business in general has fallen to very low levels. Artificial lighting escaped the depression for several reasons. In general, it had not passed beyond the primitive stage of development. It had experienced no booms. It had never been overproduced nor oversold. During the past score of years prosperity aided in lighting development, but the fundamental causes were largely natural. Only a relatively small portion of the efforts of most of the interests which profited by lighting was aggressively developing it. Even a still smaller portion of the facilities of the lighting industry was devoted to the revelation of fundamental knowledge pertaining to the hidden values of light and lighting.

Natural causes of lighting development are still at work, but most of them have slowed down temporarily. For many years wired homes were added to electric service lines at the rate of about a million annually. The country witnessed an enormous industrial development. Electrical advertising and other fields grew by leaps and bounds. Increased traffic brought forth traffic lights. New fields of lighting, such as aviation, were the result of natural progress in invention. These natural causes are still at work, even though slowed down by the ebb of prosperity. But in all this development there were no booms.

From the broad viewpoint of real value the level reached by lighting was seldom above the grade of bare necessity. From the viewpoint of human efficiency, behavior and welfare, lighting had not generally emerged from the primitive stage. This is the reason that the lighting business has not suffered appreciably in the past three years. There was no extravagance to be curbed. One needs the meager lighting of the present just as one needs other bare necessities, such as food and clothing.

Although natural causes will continue to aid lighting development, most of the increase in the lighting business will depend upon modern cultivation of old fields which have been tilled primitively. Old methods are as unjustifiable as in farming. Old fields need fertilization with new knowledge. New seed and modern tools, represented by new ideas and broader viewpoints, will greatly increase the yield of the old fields. And for a long time there will be no danger of overproduction in this direction.

Seeing versus vision

In nearly all fields of lighting light has been purchased more or less vaguely for the purpose of seeing. Certainly it has not been generally sold on an adequate basis of improved seeing. Scientific considerations of seeing have entered very little into lighting practice, for the good reason that until recent years little has been known about seeing. The eyes and the visual sense have long been studied, but such researches have yielded little more than a science of vision. Seeing is a much more extensive matter than vision, because it includes vision. Seeing is a super-complexity consisting of three complexities. The external world of objects, backgrounds, brightnesses, colors, foot-candles, highlights and shadows is generally a physical one. The eyes and visual sense constitute a complex instrument between the external complexity and an internal psycho-physiological one. These three complexities are a chain or cycle between the visual task and the performance of it. The important end-products are the efficiency, behavior and welfare of human beings as *human seeing machines.*

Lighting cannot emerge from its primitive stage until those who promote lighting appreciate that a science of seeing is now evolving and that upon this foundation

light and lighting assume the importance which they are entitled to. Supplying a few foot-candles upon a horizontal plane is not a marvelous achievement, nor does it entitle anyone to a professional standing of consequence. Civilization needs "seeing" specialists who can serve owners and employers of eyes and the lighting business. Eye specialists treat and sharpen the visual tools. They do not serve the world as seeing specialists, but they are bound to extend their field of service.

Ask any one, How do you see this or that? What factors are involved in seeing? or Why do poor seeing conditions affect the human being? The inadequacy of the replies is ample proof that knowledge of seeing is scanty. The entire world of artificial lighting is alive with myriad problems of seeing. Fig. 1 is a good example of artificial lighting from the older viewpoint of lighting practice. Local sources of light are provided for each operator, but how much knowledge of seeing was used as a basis of this installation. Light is provided just as eyesight is inherited—for the worker to do what he can with each. The foot-candles are not provided with a knowledge of seeing requirements back of their specification. In Fig. 2 foot-candle intensity is only a small part of the entire complexity of seeing for the skilled mechanic engaged in difficult visual tasks. These and nearly every other glimpse of workers engaged in visual tasks reveal lighting for seeing as a complexity far overflowing the confines of engineering. Many physical factors, visual functions and psycho-physiological effects are so involved that only a new science of seeing can co-ordinate them.

The human seeing-machine

A few years ago the author and one of his colleagues, Frank K. Moss, developed Fig. 3 as a diagram of the human seeing-machine at work. This was not entirely supported by quantitative data, but was a result of many years of research whose aim was to lay the broad foundation necessary for a science of seeing.[1] Along the horizontal axis intensity of illumination was plotted. Any other factor in seeing could have been used, but in the present primitive stage of lighting intensity of illumination is the most generally important factor for improving seeing. Occasionally one may expend the maximum amount of energy in trying to see something, but usually this would not be the case.

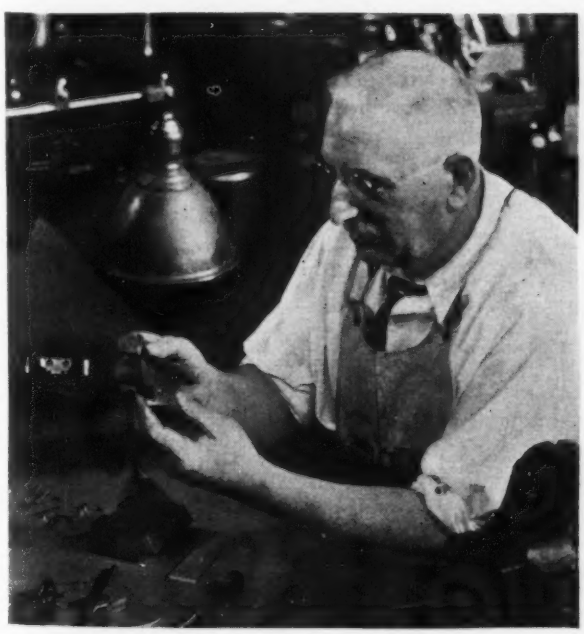


Fig. 2—These old eyes have small pupils and are dulled by time. They need several times more light than average adult eyes

No work which involves seeing can be done when there is no light. As the intensity of illumination increases the rate of production increases. The shape of the production curve depends upon the character of the visual task. For rough tasks merely guided by vision the rate of production reaches a practical maximum at a few foot-candles of illumination. The greater the difficulty of the task the higher is the foot-candle level at which production is practically a maximum. Furthermore, this level of illumination for practically a maximum rate of production generally increases with the importance of vision. For example, quantity of light aids more in purely visual work, such as proofreading and some kinds of inspection, than in manual work merely guided by vision. The difficulty of the task depends upon the fineness of details to be seen, upon the contrasts, upon the reflection factor of the backgrounds, upon the foot-candle level, upon the time available for seeing and upon many other factors.

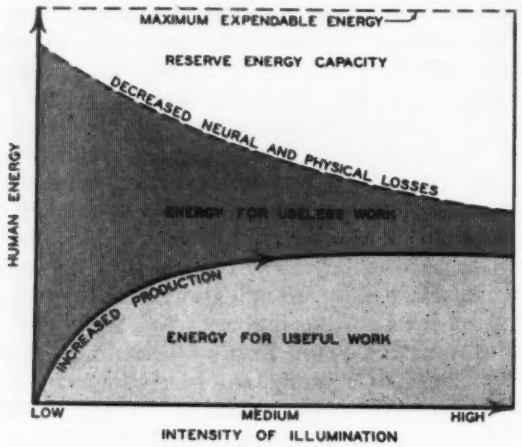
The energy that a human seeing-machine expends in useful work is represented as indicated in Fig. 3. The rate of production reaches almost a maximum in many ordinary visual tasks at levels between 20 and 30 foot-candles. These may be termed productive foot-candles. Although the production of a worker is important to both himself and his employer, production is very generally an inadequate appraisal of the benefits of light and lighting. We proved in various researches that the rate of production in visual tasks, differing enormously in difficulty and wear and tear upon a human seeing-machine, may not differ markedly. For example, printed matter which was vibrating in a very annoying manner could be read about as rapidly under a given intensity of illumination as when stationary. In the former case the task was enormously more trying than in the latter case. Thus, production as a basis of appraising lighting levels penalizes the willingness and ability of human seeing-machines to compensate for poor conditions for seeing.

Welfare enters into production

From the viewpoint of production the efficiency of a worker is measured by the rate of production or the amount of work done in a given time. This does not take into account the welfare of the worker, nor is it a measure of the efficiency of a human being as a seeing-machine. Just because one can see under a given lighting condition is not even an indication that he is seeing with maximum ease, certainty and over-all efficiency. The upper part of Fig. 3 was designed to take into account the factors heretofore entirely ignored in social science and in lighting practice. This portion of the diagram was added so that the efficiency of human beings as seeing-machines could be viewed at least as the ratio of the useful work done to the total useful

[1] *"Seeing—A Partnership of Lighting and Vision," M. Luckiesh and Frank K. Moss, Williams & Wilkins, Baltimore, 1931.*

Fig. 3—The human seeing-machine as affected by intensity of illumination, which is the generally controllable and beneficial factor in seeing



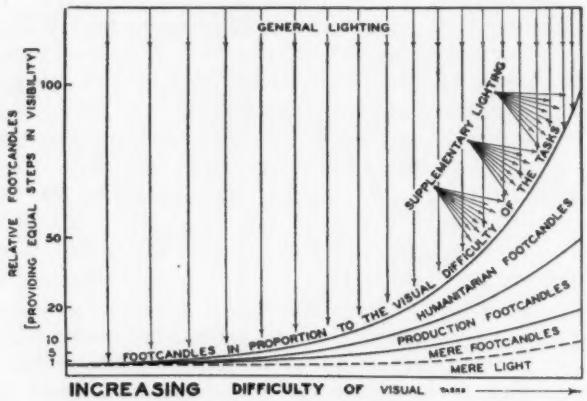


Fig. 4—Humanitarian foot-candles is the ultimate lighting level dictated by the science of seeing

The lower levels represent former successive ideals.

and useless work done. From pure reasoning and meager data a broken-line curve was drawn so as to represent pictorially the decrease in useless internal work done by the human seeing-machine as the intensity of illumination (or any other seeing factor) was improved far beyond the point where production ceased to increase appreciably owing to other limitations of the worker.

This brief glimpse of a new viewpoint toward lighting for visual tasks does not permit a detailed discussion of our recent work, which greatly strengthens the important view shown in Fig. 3. However, Frank K. Moss and the writer have recently completed an extensive research[2] in which conclusive quantitative data have been obtained to show that the nervous muscular tension of human beings engaged in a relatively easy task of reading markedly decreased as the intensity of illumination was increased to 100 foot-candles. There was no indication that this benefit to human seeing-machines ceased at this point. In fact, it seems likely that the internal strain in subjects engaged in reading excellent typography (12 point type in black ink on non-glossy book paper) would continue to decrease if the intensity of illumination were increased to hundreds of foot-candles.

Any one seriously studying the problems of seeing could scarcely believe that a few foot-candles were best for human seeing-machines who evolved through eons under outdoor environments where lighting levels are measured in thousands of foot-candles. Man-made environments, in which relatively low intensities of illumination prevail, could scarcely be expected to be improvements upon natural environments in which light has long been available in abundance. From many considerations the writer has often ventured to estimate that the ideal intensities of illumination for serious visual tasks would eventually be found between 300 and 1,400 foot-candles.

The importance of the measurements of nervous muscular tension in human beings engaged in visual tasks can scarcely be overestimated. For the first time conclusive quantitative data show an important benefit in quantity of light far above the range of intensities necessary for maximum or nearly maximum rates of production. Furthermore, this research is the first indication that average daylight intensities outdoors perhaps are, as one concludes from philosophic reasoning, the most desirable for human beings.

Although space does not permit a detailed presentation of this recent work, the significance of nervous muscular tension will be briefly discussed. One tires from strain as well as from muscular effort. A prizefighter is fatigued by nervous tension; so is one who addresses an audience. Many other examples may be cited. In any of these cases, as confidence is gained, the tasks are less fatiguing due to a decrease in nervous tension. One grips the steering wheel of an automobile more tightly when conditions of seeing are poor, as at night or in fog. Adequate light does much to reduce this useless expenditure of energy. We have termed this nervous muscular tension because it is a combination of tense nerves and muscles and is measured by muscular tension. This is a cause of much wasted energy, and this waste, usually unrecognized, takes place in any serious visual task. It has now been proved by adequate and conclusive data to be markedly reduced even for a relatively easy task of reading.

A new tool has been perfected for measuring the beneficence of lighting. The psycho-physiological realm, which has been too generally ignored in lighting practice, has now been successfully invaded. The new viewpoint which our researches have developed is ready for lighting practice. It recognizes that intensities of illumination as high as can be practically produced are justifiable when the efficiency, behavior and welfare of human beings, operating as seeing-machines, are taken into account. It recognizes that present-day artificial lighting is primitive in viewpoint and in effectiveness. This broader viewpoint introduces new values in lighting in which costs have been overemphasized in comparison even with the previously known values.

Recommended foot-candles

Social scientists have studied many factors pertaining to workers, such as rest period, supervision, attitude and hygiene. Eyes have been examined and protected, but seeing in its broad aspects, including light and lighting,

[2] *"The Human Seeing-Machine," M. Luckiesh and Frank K. Moss, I.E.S. convention, 1932.*

has not been adequately studied. This is inexplicable excepting on the basis of the absence of a science of seeing and, therefore, an absence of such a viewpoint. Certainly, eyesight is the most important physical asset which human beings possess, and seeing is the most generally important function they perform. Social scientists should be primarily interested in the real efficiency of human machines and in their behavior and welfare as human beings. For example, rest periods have been found to be beneficial both to employees and to employers. Referring to the clear area in Fig. 3, indicated as reserve energy capacity, it is found that foot-candle intensities far greater than the so-called productive intensities create a continuous partial rest period which is operative even while workers are working.

Present lighting is meager

The new viewpoint and opportunities created by the science of seeing make present-day foot-candle recommendations and practice appear in their true meagerness and primitiveness. The few foot-candles recommended for schoolrooms may be increased five or ten times, if the welfare of children is sincerely and adequately borne in mind. Intensities of 10 or 20 foot-candles in offices and factories are sufficient if workers are to be considered as mere physical machines or as workhorses. As human beings with a right to be maximally efficient in the use of their resources—visual sense, nerves, muscles and energy capacity—they have a right to many times the prevailing intensities.

Factors of safety should have been introduced long ago into lighting for the welfare of human seeing-machines. Productive footcandles[3] should be replaced by humanitarian foot-candles if we are to justify our artificial world—material civilization—from the viewpoint of human welfare. In Fig. 4 are shown various foot-candle-levels in the progress of lighting. The vertical scale is logarithmic, graded into equal steps of foot-candle effectiveness, as determined by the writer and his colleagues, particularly Frank K. Moss, through many years of tedious research. This foot-candle scale is relative, but we have recommended a scale for artificial lighting representing approximately equal steps in improvement of seeing as follows: 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1,000 foot-candles. From many studies of human beings as seeing-meters it has been shown that intensities of illumination must be doubled in order to produce an obvious, significant or appreciable improvement in seeing. The seeing specialist will recognize that human beings are very poor seeing-meters. The lighting specialist must also recognize this and depend upon the science of seeing, which is being constructed from statistical data obtained in properly controlled laboratory experiments.

See-levels in lighting are of importance far beyond the work-world of office and factory. They are important in every activity in which seeing is a factor. They apply everywhere indoors and outdoors. The science of seeing already encompasses many established facts and relationships. In the home grandmother in an easy chair needs several times more light than the average person 20 years old. This is because her pupils have decreased in size with age and her visual instrument has become dulled. More light helps those persons most who need help most. It aids slower workers more than it does faster workers. It aids old persons more than it does average adults. It aids those with defective vision more than it does those with normal vision. In this sense it is partial in its beneficence while aiding every one. It has been assumed that the increasing prevalence of defective vision with age and with the severity of the visual tasks in various industries is due somewhat to inadequate lighting. With the development of the science of seeing, into which are being coordinated many data gleaned from the three complexities—the external, the visual and the psychophysiological—inadequacy of light is being revealed as a major cause of prevalent defectiveness. Perhaps even many hereditary defects will be traced to inadequacy of light during past generations.

Figs. 3 and 4 present briefly a new viewpoint in lighting. They are already reinforced by an overwhelming mass of data[1] which reveal new opportunities in old fields of lighting. They reveal the primitiveness in lighting practice of the present and show why there could be no appreciable depression in lighting which has supplied merely the bare necessities of light as a commodity. The new science of seeing opens a panorama of opportunities for lighting development which should receive a mighty welcome at any time, and more so in this period of low tide in business activity. A new era in lighting is at hand.

[3] *"Recommended Foot-candles." M. Luchiesh and Frank K. Moss, Transactions, I.E.S., 26, 1931, 1061.*

N.E.L.A. Is an Open Book

THE National Electric Light Association has solved many industry problems which could not have been settled without it. . . . I am familiar with everything that is in the record of the Federal Trade Association inquiry, and in never a single fact that has been asserted by the association in what some people choose to call propaganda was there a single inaccuracy. The criticisms are willfully distorted for selfish purposes by a certain group who believe that the American system of private initiative is wrong. The good done by the association should not be forgotten by the few things which have brought a little notice, perhaps undesirable, toward the organization. . . . There is not a thing which is being criticised but what can and will be corrected by either the municipality or the state, and I would prefer that it be done by ourselves. This business is still in its swaddling clothes, and we are going, if left alone, to make it the greatest business in the world. To do this we must have encouragement, honest dealing, appreciation, and be treated as citizens and not as outlaws. . . . Our story is an open book.

From an address by
B. F. WEADOCK,
Executive Director N.E.L.A., at Bretton Woods, N.H., to the New England Division.

Economic Balance Between Steam and Hydro*

By K. M. IRWIN[1] and JOEL D. JUSTIN[2]

Points out that each proposed hydro development should not be measured against an equivalent steam installation as a sole source of power.

Necessary to forecast the characteristics of the particular system in which additional capacity is required and to determine for the particular conditions whether the addition of steam or hydro will give the lowest total cost of power supply for the system.

THE downward trend of steam-plant operating costs has often been cited as a reason for favoring steam as a source of power. During the past twenty years there has been a remarkable increase in steam-plant efficiencies which seem impossible or unlikely to be duplicated, although it may still be unsafe to predict what the future may offer.

It is interesting to refer to a chart that was presented in the July 4, 1925, issue of the ELECTRICAL WORLD and taken from a paper presented before a meeting of the A.I.E.E. The footnote to this graph states: "This curve . . . represents the weighted average in connection with the performances plotted for 22 stations. . . . The dotted extension of the curve is our estimate as to the future possibilities in the way of improved performance for a station designed to operate on the straight steam cycle with a single stage of reheating." Points on this graph are as follows: 1913—22,500 B.t.u. per kilowatt-hour; 1916 to 1921—19,500 B.t.u. Then appears the sharp downward break which reached 14,500 B.t.u. by 1925. The "dotted extension" from 1925 straightens out until in 1929 it reaches 13,000 B.t.u. and has been extended flat at 13,000 B.t.u. as far as 1932. In 1931, however, at least one plant with a single stage of reheat averaged 12,000 B.t.u. for the year and was operating between 200 and 300 B.t.u. less than 12,000 for six months. While predictions of future steam efficiency seem extremely unreliable, it is safe to say that the best which can be foreseen is approximately 10,000 B.t.u. when utilizing steam at 2,500 lb. and 1,000 deg. F. and 8,500 B.t.u. with the mercury cycle.

Component parts of steam-operating costs

When estimating the cost of blocks of power under system load curves from various existing or contemplated steam plants it is necessary to break these costs into their component parts. The commonly used division is between the fixed charges and the operating costs, considering the fixed charges as a cost per kilowatt of capacity and the operating expenses as costs per kilowatt-hour. A very much more accurate forecast can be prepared if the operating expenses are also divided into their component parts, which might be termed "fixed component," "peak prepared" and "increment cost of energy." There are certain annual costs which accrue in a steam plant regardless of the peak load carried or the amount of energy generated. This is termed the "fixed component" and includes portions of the superintendence, labor, supplies and expenses, maintenance and a small amount of fuel. The second component is caused by having the station prepared to supply a given load. Included in this item, besides superintendence, labor and maintenance, must be the fuel necessary to keep the required generating capacity turning over at no-load output. This expense varies with the kilowatt load that the plant prepares to carry. If the first two components have been properly allocated the variable cost is directly proportional to the amount of energy generated, and therefore can be reduced to a cost per kilowatt-hour.

For preliminary economic studies, such as those discussed herein, it is feasible to use only two factors (annual capacity cost per kilowatt and energy cost per kilowatt-hour), the first as the total of the first three items mentioned and the second the variable. It should be

Table I—Cost-Elements of Some Typical Steam Plants

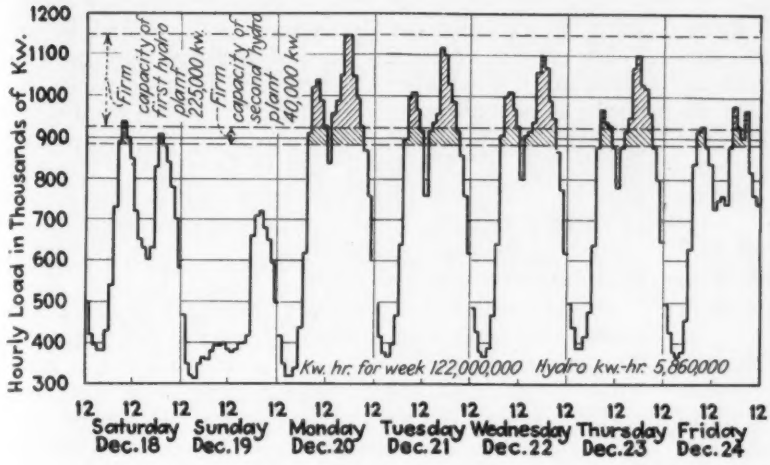
1	2	3	4	5	6*	7
Plant	Date Built	Fuel Cost, Cents per Million B.t.u.	Capacity, Kw.	Fixed Operating Cost per Kw.	Annual Capacity Cost per Kw.	Variable Operating Mills per Kw.-Hr.
A	1930	13.5	120,000	$2.10	$14.10	1.73
B	1926	15.35	130,000	4.50	16.50	2.42
C	1920–1926	18.05	135,000	4.73	16.73	2.63
D	1924–1927	17.85	215,000	4.52	16.52	3.32
E	1923	9.54	27,000	11.42	23.42	3.46
F	1917–1921	17.75	160,000	11.80	23.80	3.27
G	1911–1915	9.54	65,000	11.46	23.46	4.10
H	1917	16.05	20,000	8.15	20.15	4.60
I	1905	17.85	17,000	13.50	25.50	6.70

*The sum of column 5 and the fixed charges assumed 12 per cent on $100 per kilowatt in every case.

[1] *Assistant to vice-president in charge of engineering, Philadelphia Electric Company. Member A.S.M.E.*

[2] *Hydro-electric engineer United Gas Improvement Company.*

**Presented before the American Society of Mechanical Engineers, Ontario, Canada.*



The upper part of the load curve contains relatively little energy. If we measure down from the peak of the curve a distance equal to a proposed capacity for the hydro plant the energy in that portion of the curve above a horizontal line drawn through this point may be determined by planimetering or otherwise. If the energy as determined is equal to or less than the amount of energy obtainable from the stream flow in a week of minimum December flow, then the proposed capacity will all be firm capacity, because it can perform the same function on the load curve as alternative steam capacity.

The foregoing assumes that there are no other hydro plants in the system. If other hydro plants are already in the system the cumulative total of their firm capacity must first be laid off, measuring down from the peak of the load. The firm capacity of a proposed additional plant will then be indicated by the width of the horizontal band immediately below, which contains an amount of energy just equivalent to energy available at the proposed new hydro plant during a week of minimum December flow.

Fig. 1—Concept of firm power illustrated by load curve for peak-load week

emphasized that in using two factors a portion of the operating expense is treated as constant per kilowatt and added to the fixed charges in place of treating only the fixed charges as a constant and all of the operating expenses as varying with output, and also that peak prepared for is assumed equal to installed capacity.

The capital cost of steam plants varies over 100 per cent. Some of the factors causing the variation are the price of materials, the foundation conditions, local building restrictions, size of installation, number of units and the amount of advance expenditure made for future extensions. The size of the plant also has a marked effect in reducing the fixed operating cost per kilowatt.

For a new plant to replace an old one on the load the cost of operating plus the cost of fixed charges must be less than the operating cost of the old plant. From Table I, therefore, the cost developed from columns 6 and 7 must be less than the cost derived from column 5 plus column 7. With relatively high load factors or long hours' use, the low increment cost of the new plants makes this replacement of new for old plants economical, but for low load factors it is often less expensive to continue to operate high operating cost plants.

Thus, the total annual cost of plant A of Table I is less than the annual operating cost for plants D, E, F, G, H and I at 30 per cent load factor, but at 10 per cent load factor only less than plant I. Likewise, plant B is less than H and I at 30 per cent, but only less than I at 10 per cent load factor.

The fixed charges referred to are made up of the return on the investment, an amount set aside for replacement fund, insurance and taxes. The first item varies from 6 to 8 per cent of the capital invested. The depreciation is variously estimated by different engineers from 3 per cent to 4 per cent on steam plants; insurance payments generally average one-half of 1 per cent. The taxes on real estate and personal property rarely exceed 1 per cent. For studies of this kind these are the only

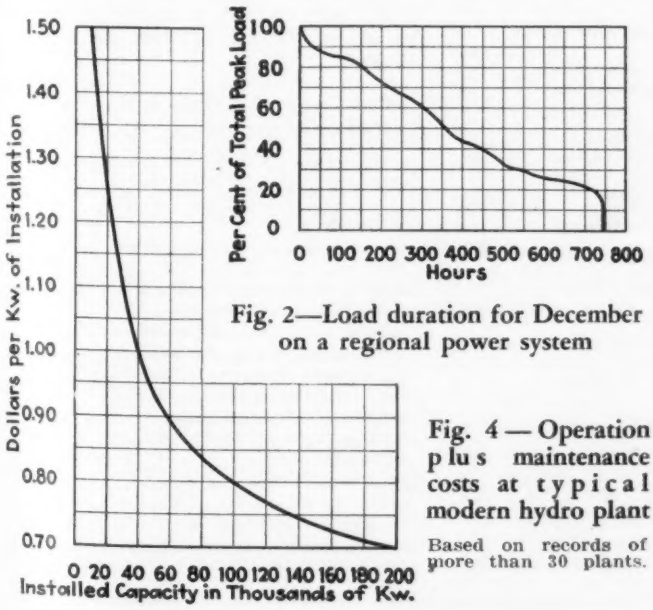


Fig. 2—Load duration for December on a regional power system

Fig. 4—Operation plus maintenance costs at typical modern hydro plant

Based on records of more than 30 plants.

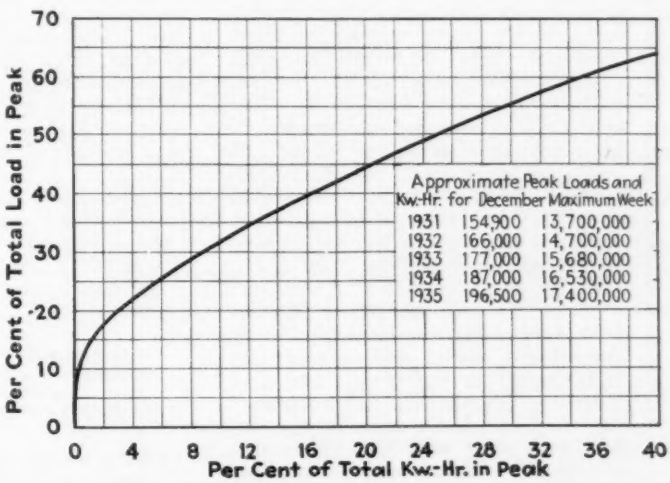


Fig. 3—Peak percentage for maximum week on a regional power system

To illustrate the use of the peak-percentage curve in as simple a manner as possible, it will be assumed that at the present time there is no hydro capacity in the system, but that the company is contemplating the development of a site to be completed for the 1934 load. At the proposed site, which has ample pondage, there will be available in a week of minimum December stream flow 906,000 kw.-hr., which from the table in Fig. 3 is 5.4 per cent of the total energy for the week. Using the curve, this corresponds to 24.5 per cent of the load. In other words, in the top 24.5 per cent of the load there is only 5.4 per cent of the total energy. As the total estimated load in 1934 is 187,000 kw., the amount of capacity which may be installed and be firm capacity in 1934 is 187,000 × 0.245 = 46,000 kw. It may, however, prove desirable to so design the project that some additional capacity may be added at a later date, particularly if river flow is such that additional capacity would generate a large amount of additional energy.

taxes that need be considered. Some states levy gross-receipts taxes in lieu of personal-property taxes, and for general corporate purposes these, together with income taxes, are often apportioned as percentage of investment and are included in the fixed charges. It is not correct to include such taxes in this economic study, because they are dependent on output or profit and bear no relation to investment.

Carrying charges in Table I have been assumed as 7 per cent return on investment, 3½ per cent for depreciation, 1 per cent for taxes and ½ per cent for insurance, a total of 12 per cent.

In any large system the power supply of which consists of both steam and hydro plants it is always feasible and generally quite economical to supply the requirements of the increasing load through the construction of additional steam capacity. If, however, the system includes available hydro sites, it is necessary to conduct quite an extensive economic study in order to determine whether the additional load can be most economically supplied by a new steam plant or by a new hydro plant.

As steam is the yardstick by which the economic advisability of hydro must be measured, about the first thing which must be determined with regard to any hydro project (after its physical features have been investigated) is whether the proposed hydro capacity can do the same work which an alternative steam plant might perform on the existing load curve. If the hydro plant can do this its capacity is said to be "firm." The firm capacity of a hydro plant may be defined as that portion of its total capacity which can perform the same in that portion of the load curve assigned to it which alternative steam capacity could perform.

The minimum 24-hour power available at the site is sometimes incorrectly spoken of as the firm capacity. This can be true only in the case where there is absolutely no pondage. With large pondage and favorable load conditions, the firm capacity of a hydro plant may be many times the minimum 24-hour power available. In the case of some existing plants which are parts of large systems and are possessed of ample pondage the firm power is ten or more times the minimum 24-hour.

The concept of firm power will be plain by reference to Fig. 1, which is the load curve of a large power system for the maximum demand and maximum energy week. In the system under consideration the maximum demand

Set-Up for a Typical Hydro Project

A power system requires additional capacity of about 50,000 kw. in order to be able to serve the anticipated load of 1934. A suitable hydro site is available, and the company desires to determine whether it will be more economical to install a hydro plant or a steam plant for the next step in the development of its power supply resources. Thorough field investigations, office studies and estimates of cost for the hydro project have been made. The pondage at the site has been determined as ample for weekly regulation with only slight drawdown. By methods already outlined, it has been determined that 50,000 kw. of capacity may be installed at the site and be firm capacity on the load curve of 1934. The energy available during a peak-load week coincident with minimum stream flow has been determined as 2,000,000 kw.-hr. Accordingly, during such a week, the plant would be operating on a load factor of 23.8 per cent. The output of the plant during the average year has been determined as 240,000,000 kw.-hr., giving an annual capacity factor of 55 per cent. The characteristics of the project are evidently such that although only 50,000 kw. capacity would be firm in 1934, a much larger installation will prove advisable at some time in the future, and accordingly provision has been made in the design for readily extending the power house and increasing the capacity. The total capital cost of the project with an initial installation of 50,000 kw. has been estimated as $8,750,000.

In accordance with the principles outlined, a careful study has been made of the transmission liability of the project, which has been determined as $3.72 per kilowatt per year of installed capacity.

The alternative steam plant would be located at the load center, and its annual cost has been determined as $15 per kw. per year, plus 2 mills per kilowatt-hour for energy.

The transmission losses are 6 per cent in capacity at time of full load, and average loss of energy would be 4 per cent. The delivered power would be 0.94 × 50,000 = 47,000 kw. and the delivered energy would be 0.96 × 240,000,000 = 230,400,000 kw.-hr. Based on these data, a set-up for the project may be made as follows:

1. Annual value of hydro power and energy delivered in an average year (based on costs at alternative steam plant):	
47,000 kw. delivered at $15	$705,000
230,400,000 kw.-hr. delivered at 2 mills =	460,800
Total annual value of hydro output delivered =	$1,165,800
2. Annual total cost of hydro power delivered:	
Fixed charges on hydro development, 9 per cent on $8,750,000 =	787,500
Operation and maintenance of plant (Fig. 4) 0.95 × 50,000 =	47,500
Total annual cost of transmission (as above) =	186,000
Total annual cost of hydro power delivered.....	$1,021,000

Hence in this case the annual advantage of the hydro plant over the alternative steam plant is $1,165,800 — $1,021,000 = $144,800.

It is believed that this method is preferable to any attempt to show return on the investment, because it shows directly the effect on the earnings statement of adopting one of alternative sources of power supply. It should, however, be recognized that the investment required for the hydro alternative is usually much greater than that of a steam plant.

Accordingly, the reaction of an executive charged with the responsibility of raising the money required might be expressed as follows:

> "If we built a steam plant to take care of the increasing load, it will cost us only $4,700,000, whereas if we build a hydro plant we must spend $8.750,000 for the plant, plus $1,550,000 for transmission, or a total of $10,300,000. In other words, we will have to spend over twice as much money if we adopt the hydro alternative. What I should like to know is, what return are we going to make on this proposed additional investment?"

This question may be answered with the aid of the data already given as follows:

Annual Cost of Delivered Hydro Power Excluding Interest on Excess Investment in Hydro

Depreciation, taxes and insurance on hydro development, 2 per cent on $8,750,000 =	$175,000
Operation and maintenance of hydro plant =	47,500
Operation, maintenance, depreciation, taxes and insurance on transmission facilities, 5 per cent on $1,550,000 =	77,500
Interest charges on cost of alternative steam plant 7 per cent on $4,700,000 =	329,000
Total annual cost of delivered hydro, exclusive of interest on excess investment of $5,600,000 ($10,300,000 — $4,700,000) =	629,000
Annual sum available for return on excess investment in hydro = $1,165,800 — $629,000 =	536,800
Return on excess investment in hydro = 536,800 ÷ 5,600,000 =	9.6 per cent

always occurs in December. The hydro project under consideration would have a large pond of ample capacity to provide weekly regulation with an insignificant drawdown. If the characteristics of the load are not already well known it may be necessary also to study load curves for many other weeks of the year, because, although the load at other times of the year is less, the load factor may be higher and the stream flow less.

The determination of firm capacity, utilizing the actual load curves and the cut-and-try methods indicated, is very laborious, and consequently the work is greatly abbreviated by the use of mathematical curves.

Peak percentage curves

To prepare a mathematical curve to be used in determining firm capacities it is first necessary to plot a load-duration curve (Fig. 2) for the period under consideration. This is done by arranging the loads hour by hour in order of magnitude and plotting, using loads as ordinates and time as abscissas. Areas underneath the curve thus represent energy. In the most convenient form of load-duration curve per cent of total load is plotted as ordinates and per cent of time as abscissas. Such a curve may be applied to many different years (assuming no change in shape of load curve).

The peak-percentage curve (Fig. 3) is obtained from the load-duration curve as follows: Beginning at the top of the curve, cumulative areas are determined by increments, by planimetering or otherwise. (Figs. 1, 2 and 3 are all for different power systems.) Use of the peak-percentage curve is illustrated by an example under Fig. 3.

The capital cost of hydro plants per kilowatt varies over much wider limits than is the case with steam plants. This is because a much smaller part of the total cost is in equipment and buildings. For any given site and head the investment in land, riparian rights and dams is very nearly a constant, regardless of the amount of installation. However, the incremental cost of installation, meaning those costs which roughly are proportional to installation, consisting mainly of building, intake conduit and equipment, vary within much narrower limits. An examination of cost data for a number of plants varying in capacity from 3,000 to over 200,000 kw. indicates that the incremental cost of hydro plants in general varies from $55 to $70 per kilowatt.

The importance of incremental cost as affecting the economics of hydro-electric plants is not generally recognized. Thus, at a given site, a plant having a capacity of 20,000 kw. might cost $7,500,000, or $375 per kilowatt. In all probability the requirements for additional power and energy could be met more cheaply by the construction of a steam plant. However, at the same site, the capacity might be doubled at an additional cost of $1,000,000. The cost per kilowatt installed would then be $212, and quite possibly the project might prove economical at such time as all the capacity became firm capacity on the load curve.

The effect of the unusually low increment capital cost of hydro installation in determining the advisable use to be made of a hydro project may be understood by a study of Fig. 5.

In order to arrive at the capital cost per kilowatt of installation for various capacity factors an actual operating modern plant on the river (considered in Fig. 5, curve C) was selected. The actual total costs were segregated in items which would be the same regardless of installation, such as land, water rights, dams, railroad changes and highway, and the items which vary with the amount of installation, such as power house, equipment, turbines and transmission. This latter group constitutes the increment cost of installation and was found to be approximately $70 per kilowatt. Starting with an installation which gives 100 per cent capacity factor (or that required to just utilize the minimum weekly flow), the installation was increased by increments and the capacity factor and cumulative cost determined for each increase in installation. To get the unit cost the total was divided by the total installation.

Curve C (Fig. 5) then shows for a fairly typical case the tremendous variation in unit capital cost of hydro according to the amount of installation installed. Thus, if the project is planned on a 90 per cent annual capacity-factor basis, the capital cost would be about $580 per kilowatt, whereas if planned on a 20 per cent annual-capacity basis the capital cost would (by curve C) be about $100 per kilowatt. It should here be noted that in

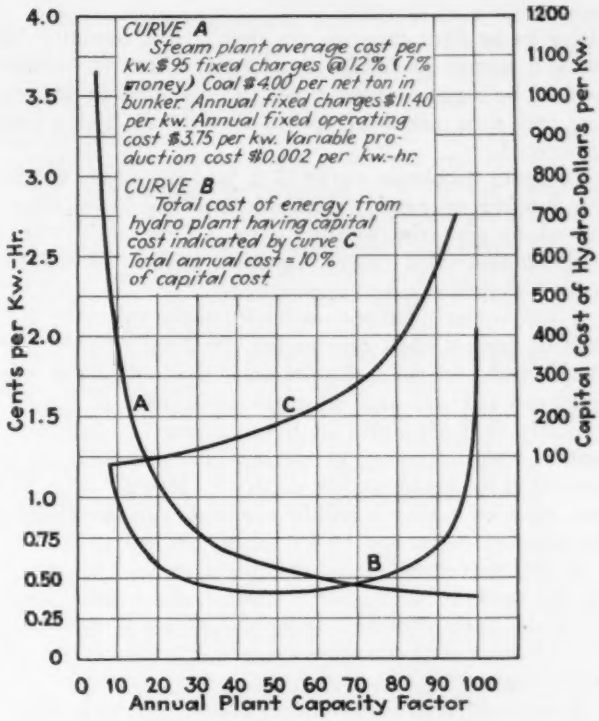


Fig. 5—Total cost of energy at various capacity factors at steam and hydro plants

Curve A in this figure gives the total cost of energy per kilowatt-hour for a modern highly efficient steam plant.

Curve C gives the total capital cost per kilowatt of installation for a hydro plant if installed for various annual capacity factors. The plant is a fairly typical hydro plant on a fairly typical American river, having an average annual runoff of about 1.5 c.f.s. per square mile and a range of flow varying from a weekly minimum of 0.15 c.f.s. per square mile up to over 28 c.f.s. per square mile. Thus the larger the installation the greater the amount of energy turned out by the plant during any given year. It should, however, be remembered that the annual capacity factor of a hydro plant decreases with increased installation. The plant has ample pondage for weekly regulation, which is a prime requisite for any hydro project if all its capacity above that required for minimum stream flow is ever to become firm on the load curve.

The curves are applicable only for the case where all hydro capacity installed would be firm capacity on the load curve. In fact, it seldom pays to consider hydro installations on a low capacity-factor basis unless all the capacity is firm.

order to be firm capacity on such a low capacity-factor basis it would probably be necessary for the connected load to be three or four times the installed hydro capacity, and thus the load would absorb all hydro energy generated.

In order to obtain curve B it was necessary to obtain the amount of energy available for the installation required to give the various capacity factors. For this purpose flow and power duration curves of the fairly typical stream selected were utilized.

Total annual charges on hydro were taken at 10 per cent of capital cost, and to get the total cost of energy the annual cost per kilowatt was divided by the energy produced per kilowatt of capacity. Curve B shows the typically very high cost of hydro energy as compared to steam at high capacity factors and its relatively low cost compared to steam on low capacity factors. At a 70 per cent capacity factor it will be noted that in the given case the costs of steam and hydro power are equal.

While there are many situations in which, if curves similar to those shown were plotted, the results obtained would be quite different from those shown, nevertheless it is believed that the curves are fairly typical for many situations.

Most emphatically the curves should not be interpreted as showing that either steam or hydro is the cheaper source of power supply. The only thing that ever makes it feasible to install a hydro project on a relatively low annual capacity-factor basis is the existence of a connected load several times the hydro capacity served largely by steam plants.

Under more or less exceptional conditions hydro plants having very high annual capacity factors are economically feasible. Niagara Falls is a frequently cited example of this.

Annual costs of hydro plants

There is a wide variation in the practices of various companies with regard to the fixed charges set up for economic studies. The actual rate utilized is not of as great importance as it is that the fixed charges for both steam and hydro plants should be on a truly comparable basis.

Cost of money should be the same in either case, but the total fixed charges on hydro should almost always be less for hydro than for steam. Depreciation should be much less for hydro than for steam, because a very high percentage of the total investment is in items that are not depreciable or that are subject to a very slight depreciation, such as lands, riparian rights and structures of earth and concrete.

In any particular case the annual depreciation should be computed item by item by the sinking-fund method. The over-all annual rate so computed will in general vary from 1.5 per cent for projects where most of the investment is in the power plant down to 0.5 per cent for a project where a large proportion of the investment is in water rights, land, earth dams and tunnels. In making preliminary studies it is usually satisfactory to select a rate of depreciation between these two limits, based on well-informed judgment. For illustrative purposes only, 1 per cent per year on the total cost of the project has been selected as representing depreciation on an average hydro plant and being fairly comparable with the 3½ per cent used on steam plants herein.

The cost of taxes and insurance is generally less for hydro plants. The relative investment in items on which insurance is issued is much less, and taxes are usually at a lower rate because hydro plants are usually located in rural sections remote from the centers of population.

Some small hydro plants have very high annual costs for operation and maintenance. Some of them with capacities of a few thousand kilowatts or less have costs for operation and maintenance up to $6 per kilowatt per year. However, with the present availability of remote control and automatic apparatus, there is probably no need for such costs exceeding about $2 per kilowatt per year. Operation and maintenance costs at hydro plants should vary roughly with capacity, size and number of units. Based on a study of the cost records of a large number of operating plants, Fig. 4 shows approximate operation and maintenance costs for typical modern hydro plants.

Based on the foregoing data, the annual costs for hydro plants have been taken as follows for the illustrative purposes of this paper: Money, 7 per cent; depreciation, 1 per cent; taxes and insurance, 1 per cent. Total fixed charges, 9 per cent. To obtain total annual cost, there should be added the annual cost of operation and maintenance as obtained from Fig. 4.

Transmission costs

When considering the advisability of adding a hydro plant to any power system, the cost of transmission is sometimes of paramount importance. Some hydro projects are located in sections remote from the center of gravity of the load and require for their utilization the construction of long and expensive transmission lines. On the other hand, in the case of some regional power companies, the additional transmission facilities required must be just as extensive if a new steam plant is built. In any given case the transmission requirements should be carefully analyzed and the additional cost of transmission which will be necessary if a hydro plant is built, but which will not be necessary if a steam plant is built, should be carefully determined. This differential cost of transmission is sometimes spoken of as the "transmission liability" against the hydro plant. In the case of large hydro projects requiring 60 to 150 miles of additional transmission for their sole use the "transmission liability" may vary from $2.50 to $7 per kilowatt per year of installed capacity.

Value of hydro energy

It is usually assumed that the value of the output of a hydro-electric plant may be determined by the annual capacity cost and the increment cost of energy at an alternative steam plant. This is necessarily true only if the annual capacity factor of the alternative steam plant would be the same as that of the hydro plant. A new steam plant would usually be one of the most efficient in the system and would have a very high capacity factor. In such a case, excess energy which would annually be turned out, multiplied by the difference in increment steam cost between the proposed new plant and existing steam plants, should be subtracted from the total value of the hydro energy.

It should, however, be recognized that this is only a temporary liability of the hydro plant. As new steam plants are added, the capacity factor of the alternative steam plant will decrease, until it will soon be no greater than that of the hydro plant. For this reason it is often

sufficient to consider this liability as counterbalanced by certain hydro advantages which may not always be readily evaluated in dollars and cents, such as peak-load service and reserve capacity.

The hydro ratio is sometimes used to express the relationship between the hydro capacity in a given system and the annual peak load of the system. The "economic hydro ratio" may be defined as that ratio of hydro installation to peak load which for the given company gives the minimum annual cost of power supply. The economic balance between steam and hydro capacity for a given system at any given time is largely dependent on the following factors: Shape and size of load curve, availability of suitable hydro sites, additional transmission facilities required for hydro ("transmission liability"), runoff and its seasonal distribution, availability and cost of storage, cost of fuel and availability of condensing water. Clearly the "economic hydro ratio" may vary from zero in sections where hydro sites are extremely expensive and fuel cheap up to 100 per cent for sections where fuel is extremely expensive and suitable hydro sites with well-regulated stream flow abundant.

In some locations where fuel is cheap, but where favorable hydro sites are available, the economic hydro ratio has been shown to be from 25 to 40 per cent. In certain other regions where fuel is somewhat more costly, but where very favorable hydro sites are available with relatively cheap storage, the economic hydro ratio is from 60 to 70 per cent. In certain sections of Canada the ratio is even higher.

A further decrease in the cost of steam-generated power will to some extent affect the economic hydro ratio, but will have more effect in changing the function of the new hydro plants constructed; that is, decreases in cost of steam will dictate the construction of hydro plants designed for lower annual-capacity factors.

▼ ▼ ▼

Land Joints and Cable Feature Submarine Crossing

By C. H. JENKINS

Underground Engineer

Los Angeles Department of Water and Power

Recent development of large loads on Terminal Island in the Harbor District at Los Angeles, Calif., made desirable the extension of 33-kv. lines from the mainland. As no satisfactory route for a tower crossing span was available, arrangements were made to install two 33-kv. submarine cables across the channel between Wilmington District and Terminal Island.

As the crossing span cables were to be laid on the channel bottom without protection from ship anchors, it seemed desirable to use some conductor insulating material which would not deteriorate when exposed to moisture, yet provide some assurance of a reasonably long life under 33-kv. operation. Type H, Okolite-insulated, armored cable was selected as best meeting these requirements and two 1,100-ft. lengths of No. 1/0 three-conductor cable of this type weighing about 12 lb. per foot were installed. The cables were laid about 15 ft. apart in one operation by placing both reels on a barge which was then towed across the channel.

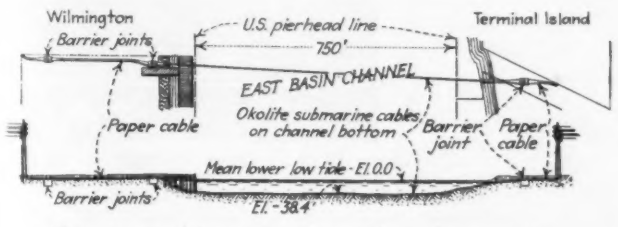


Fig. 1—Position of 33-kv. submarine crossing

Oil barrier joints were installed in the manhole adjacent to the pole and between the paper-insulated cable and the Okolite cable. This joint, which is a modification of the department's standard oil barrier joint, consists essentially of a brass diaphragm in which are gasketed three bushings, each consisting of a copper rod wrapped with impregnated paper. Okolite tape was used for conductor taping on the Okolite cable end, and that portion of the joint was filled with Ozite compound for vulcanizing the Okolite tape and for insulation. Paper tape was used on the paper cable end. The mechanical joint between the Okolite cable conductor and the oil barrier joint bushing is designed to slip free under stress of considerable tension on the submarine cable, and the diaphragm is anchored to the end wall of the manhole. This provision is made to free the submarine cable without damage to the paper-insulated cable should the submarine cable be caught by a moving object and displaced.

After completing the installation of joints and terminals the paper-insulated cable sections were evacuated to 29½ in. of mercury. The joints and terminals were then filled with degasified transil oil. The department's standard cell-type oil reservoirs were installed in the manholes and on the poles, connected to the paper cable, and left to operate under 2 lb. per square inch minimum pressure.

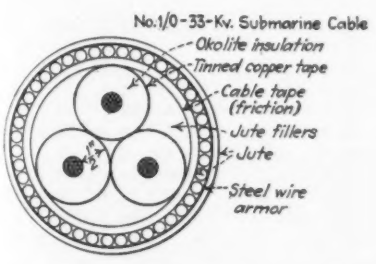
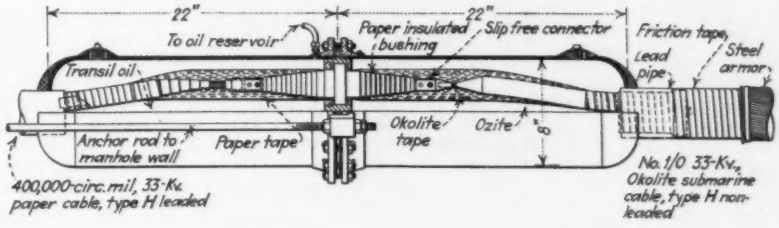


Fig. 2—Cross-section of 33-kv. submarine cable

Fig. 3—Three-conductor oil-barrier joint used at land ends of submarine crossing



July Industrial Energy Sag Smaller Than Usual

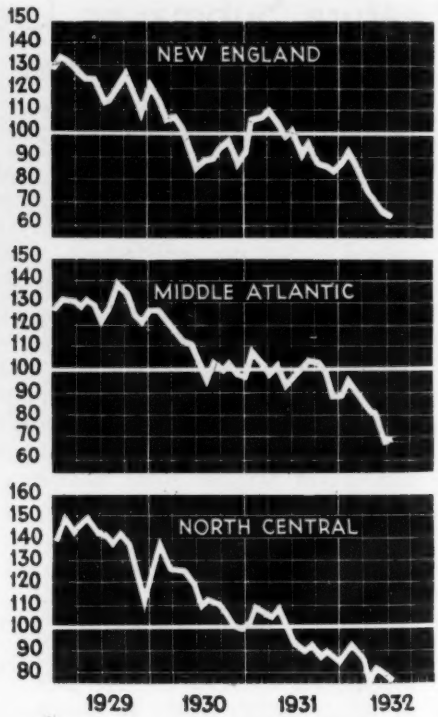
Industrial activity fell off 1 per cent from June to July, gaged by statistics on energy consumption reported to the ELECTRICAL WORLD. The decrease was smaller than in other recent years; it compares favorably with the 5 per cent in 1929, 9 per cent in 1930, 4 per cent in 1931. The current index, 77.4, is 43 per cent below the highest previous July (1929) and 10 per cent above the lowest (1924) in the present series, which was begun in 1923. Although operations are still 21 per cent below last year's for the corresponding month, the gap seems to be closing; the percentage in May was 25, in June 23.

Most of the changes from June in the individual industry groups were small. Further gains are indicated in food products and chemicals, the latter including oil refining. Leather products recovered, returning approximately to the level of May. Textiles remain unchanged, 43 per cent below July, 1931, and at the lowest point for any month since the series was begun. Rubber products returned to the May level after the remarkable spurt to which attention was called in the discussion for June.

In the manufacture of automobiles and parts the rate of operations was about the same as in June, and materially higher than in the corresponding month of last year.

Regionally, of the three industrial areas here listed only the Middle Atlantic states show a rise over June. Conditions in the South and West will be presented in next week's issue, when fuller returns are expected to be available.

In New England metal working fell off severely; the textile industry continues at an unusually low ebb, but the shoe industry, chief branch of "leather products," advanced more than in 1931; the average declined 4 per cent. Middle Atlantic chemicals, foods and textiles advanced; sharp reductions in cement mill operations caused a further decrease in the index of the stone, clay and glass group. In the North Central area the last-named industry held up much better, according to returns thus far available; the largest factor contributing to the 3 per cent decrease in the general average for that section was the reduction in rubber.



Index of monthly manufacturing activity

Base: Average month 1923-1925 = 100.

(Corrected for number of working days, but not for seasonal variation.)

These data are compiled by ELECTRICAL WORLD and are based on monthly consumption of electrical energy by 3,800 large manufacturing plants in various industries and scattered throughout the country.

	United States				New England				Middle Atlantic				North Central			
Industrial Group	July, 1932	June, 1932	May, 1932	July, 1931	July, 1932	June, 1932	May, 1932	July, 1931	July, 1932	June, 1932	May, 1932	July, 1931	July, 1932	June, 1932	May, 1932	July, 1931
All Industry	77.4	78.1*	82.0	97.9	64.0	67.3	71.0	100.6	69.3	68.5	78.5	95.7	77.5	80.2	82.7	92.1
Automobile (including parts and assessories)	66.0	65.9	69.3	55.9	.....	.....	.....	.....	47.5	50.1	66.2	43.2	65.3	65.0	69.0	57.0
Chemical products (including oil refining)	125.7	123.8	129.9	137.7	141.2	143.0*	149.8	155.4	135.3	131.0	138.2	155.2	117.4	115.3*	119.0	124.0
Food products	122.0	118.4	116.3	147.0	.....	.....	.....	.....	97.3	94.9	92.3	117.1	124.0	123.7	119.7	150.0
Iron and steel	53.9	55.8	61.8	83.1	85.3	79.4*	78.8	119.1	47.4	49.2	52.1	72.0	55.8	57.8	66.2	83.8
Metal working	51.0	53.0*	55.8	69.3	51.2	68.5*	71.5	96.4	50.8	49.8	54.5	64.3	48.5	53.7*	54.7	67.0
Metals group	52.2	54.1	58.1	74.5	60.8	71.5	73.6	102.8	49.4	49.6	53.4	67.5	51.8	55.0	59.2	73.3
Leather products	73.7	65.7	74.7	83.8	72.8	61.2	60.8	77.8	86.0	80.7*	97.8	88.7	58.0	51.8	59.7	82.7
Forest products	69.2	70.0	77.8	76.9	39.0	43.9*	41.8	52.0	51.3	48.1*	62.7	95.0	70.0	71.5*	80.8	95.2
Paper and pulp	93.0	95.8*	102.7	104.0	97.7	106.1*	109.4	156.0	51.0	60.2	67.5	66.8	89.3	94.2	99.2	101.7*
Rubber products	95.6	120.7	95.5	97.4	85.4	89.7	84.2	78.6	.....	.....	.....	.....	95.7	126.4	96.9	120.6
Shipbuilding	82.5	85.1	86.8	82.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Stone, clay and glass	80.6	87.1*	97.9	104.8	.....	.....	.....	.....	58.0	72.7	85.7	97.3	107.3	109.0*	118.3	100.3
Textiles	55.0	55.2	62.8	98.2	42.0	42.6*	48.2	90.6	65.6	58.0	80.2	114.4	74.6	79.3*	91.5	98.3

*Revision.

Lightning Data and Line Protection

By F. W. PEEK, JR.*

General Electric Company, Pittsfield, Mass.

Theory of cloud charge and discharge.
Experiments and computations on magnitudes.
Protection of transmission lines.

EARLY investigators found that water drops broken by air currents become positive while the air becomes negative. It is well known that there are always violent upward air currents during thunderstorms. There seems to be little doubt that these upward air currents break up the larger falling water drops, thus separating the positive and negative charges and carrying them to the clouds. If this process continues for a sufficient time the electric stress or gradient between clouds or parts of clouds or between cloud and earth becomes high enough to cause breakdown.

The thunder cloud is made up of innumerable small charged water particles floating in the insulating air. Any part of a cloud may be thought of as made up of charged and insulated shot very close together. If the charges on this section are approximately equal, the effect is approximately the same as from a metallic surface; it is sometimes considered as a volume distribution of charge. Just before the main discharge takes place the initially insulated water particles probably become connected together by ionization and sparks. The preliminary stages of breakdown may usually require many seconds, while the final complete breakdown coincident with the collapse of the field and the sudden release of the bound charge may be a matter of microseconds. Sparkover in the laboratory at sea level between points for continuously applied voltages takes place at about the average gradient of 160 kv. per foot for gaps up to about 20 ft. in length. Lightning sparkover to earth seems to occur when the gradient near the earth becomes about 100 kv. per foot.

It would thus appear that the ordinary lightning stroke, 1,000 to 2,000 ft. in length, takes place at voltages of the order of 100,000,000 to 200,000,000.

Time and rate of discharge of a lightning stroke

While it usually requires minutes to charge a thunder cloud, the observations indicate that the discharge of the cloud may in some cases take place in a few microseconds. When a charged cloud approaches a transmission line charges of opposite sign leak over the insulators or appear on the lines from the terminals. These charges are bound to the cloud charge by the electrostatic field. When the cloud discharges according to some time function, voltages appear on the line and two identical traveling waves are eventually formed. The shapes of measured waves indicate that the time function may vary from linear to exponential. It has been found from a mathematical study that the length of the bound charge on the line is practically the same for a point, line, spherical or cylindrical cloud. Accordingly, the lightning wave shape is practically independent of the distribution of cloud charge. It was also found that the length of the equivalent rectangular bound charge is equal to twice the height of the center of gravity of the cloud, and that the front of the resulting traveling waves is approximately equal to the length of the bound charge. Data show that the length of the tail of an induced wave and the total length of the first half cycle of a direct stroke wave are a measure of the time of cloud discharge.

From which follow:

(a) The height of cloud = ½ (length of bound charge on line) = ½ front of induced wave.
(b) Time of discharge = (total length of wave-front).

Thus an undistorted wave gives the height of cloud, time of discharge of the lightning stroke, length of bound charge on the line and law of cloud discharge. The voltage can be approximated by multiplying the height of cloud by the breakdown gradient of 100 kv. per foot. The indicated usual range of cloud discharge is approximately 5 to 400 microseconds. The fronts of many waves vary from 1 to 7 microseconds, and thus indicate bound charges varying from 1,000 to 7,000 ft. in length and cloud heights varying from 500 to 3,500 ft. The average cloud height indicated was 1,500 ft.

While the polarity of most low, and probably induced voltages, is (+), the polarity of most high and probably direct stroke voltages is (—). Both indicate that most of these disturbances originate from a (—) negative cloud. The time of cloud discharge may also be found from a direct stroke wave. It is then the time from the start until the wave passes through zero.

Lightning discharges are generally impulsive or highly damped oscillations. Freqently a number of strokes follow one another in rapid succession.

Current—charge and energy

Approximate values of the current of a lightning stroke have been arrived at in several ways, as follows:

(a) *Direct measurements of the current in towers struck by lightning.*

(b) *Wires volatilized by lightning*—The limit of lightning current with time or the charge can be fixed by wires known to have been volatilized by lightning.

(c) *Measurements from oscillograms showing time of cloud discharge*—When the length of time and rate of cloud discharge is fixed the current of the discharge is also fixed. The two are interdependent. The oscillograms of undistorted traveling waves give the time of discharge and indicate the manner of discharge, which seems to vary from a linear rate to an exponential rate. The exponential and linear rate of discharge thus give the

*Abstract of paper presented before International Electrical Congress, Paris, July 4-12, 1932.

maximum and minimum currents for a given time of discharge. The order of current indicated in this way is the same as that indicated for severe strokes in methods (a) and (b) above. The value of current calculated in (c) above is limited only by charge, rate and time of discharge. Ultimately the current is limited only by the voltage and the resistance.

The above data indicate that direct stroke lightning currents may vary from a few thousand to several hundred thousand amperes. The charge in severe strokes is from 1 to 20 coulombs and in the less severe stroke as low as 0.1 coulomb. The lowest value is based upon the current of 10,000 amp. with a total duration of 30 microseconds, the average measured time of discharge.

The energy of lightning discharges indicated from the above measurements varies from 3 to 100 kw.-hr.

The current charge and energy of lightning strokes vary over a wide range. The above values give the order of this range for a large number of observations. It is possible that much less severe and much more severe strokes also occur.

Lightning on transmission lines

The various factors affecting lightning transients on transmission lines and their order of magnitude are as follows:

Height of cloud = 500 to 3,500 ft., 1,500 to 2,000 ft. average.
Time of cloud discharge—5 to 500 microseconds, 50 per cent of observed values less than 30 m.s.
Gradient near earth—100 kv. per foot.
Current—10,000 to 500,000 amp.

Oscillograms of traveling waves give remarkably complete characteristics of the lightning which produces them. Direct stroke and induced voltage phenomena are dependent upon each other by definite laws and it is not possible to determine one on assumptions that violate the other. Accordingly, the induced wave records the direct stroke characteristic as well as the induced characteristics. Possible effects of induced voltages and direct strokes on transmission lines will now be discussed.

Induced voltages

Induced voltages, which are of a polarity opposite to that of the cloud, can be calculated from the following formula:

$$V = gh\alpha \qquad (1)$$

Where V is the maximum voltage to ground and g is the gradient (maximum 100,000 volts per ft.), α is a factor depending upon the time of cloud discharge and distribution of the bound charge and is always less than unity; α would be unity if the cloud discharged instantly. The practical range of α, which is readily calculated, is fixed between linear and exponential discharge. The exponential discharge is the more probable. α gives the maximum induced voltage at the point of origin. The range of time of discharge is determined by oscillograms on transmission lines. Since the direct stroke current is also determined by α, any induced voltage requires a given direct stroke current. The measured direct stroke current is thus a check on the possible induced voltage.

An examination of the data shows that voltages of 2,000 kv. or more are possible with the time and current limits observed on actual lines. For example, for exponential discharge from a 1,000-ft. cloud an induced voltage of 2,500 kv. requires a current of 410,000 amp. in the stroke and a discharge time of 11 microseconds. For higher voltages the current must be much higher than observed or the time of discharge shorter. These voltages are also based upon the line being directly under the cloud. It appears, therefore, that while such voltages can occur and probably do, the probability of their frequent occurrence is not great; 2,000 kv. is the order of the lightning sparkover of a 230-kv. line (fourteen to sixteen insulator units). It would thus appear that only a very small percentage of lightning troubles on 230-kv. lines could be due to induced voltage and such troubles should be practically or entirely eliminated with ground wires. Thus both the possibility and the probability of these phenomena are important. As line insulation is decreased below 1,500 kv. the chance of induced voltage troubles is increased, especially if ground wires are not used.

When ground wires are used, equation (1) becomes

$$V = gh\,q\,\omega \qquad (2)$$

Where

g = 100,000 volts per foot.
h = average height of conductor in feet or meters (in dry, sandy or rocky country; with high resistance ground effective height may be higher than indicated by height of line).
q = usually less than 0.5.
ω = protective ratio of ground wire 0.5 or less, depending upon conductor arrangement.

A ground resistance of less than 50 ohms is desirable.

It can be concluded that:

1. Low lines are desirable.
2. Ground wires are desirable.
3. As the insulation is reduced or the conductor height increased, induced voltage sparkover becomes of increasing probability.
4. Induced voltage troubles can be eliminated by ground wires on high and moderate voltage lines.
5. Very high induced voltages are possible under favorable conditions. The probability of such conditions occurring frequently does not seem great.

Chance of being struck

The chance of a line being struck increases with increasing height of line. On a flat surface without projections a tower may be hit when the distance from the projection of the storm center is less than four to ten times its height. This factor is based on the assumption that the nearest object will be hit and has been called the direct hit ratio, r. This ratio is approximate since laboratory work shows it is affected by polarity. The danger zone is narrower for (+) clouds. By applying a factor of safety both polarities are covered.

A direct stroke may go to the ground or to a 50-ft. tower when the projection of the storm center comes within 300 ft. of the tower. In this case, a direct hit may take place to the tower when the storm center is above a zone 600 ft. wide with the line as center. For a 100-ft. tower and a 1,000-ft. cloud this strip would be 800 ft. wide. When there are projections on the surface the chance of a given object being hit is reduced. Trees of even moderate height, within several tower lengths of the line, greatly reduce the danger zone and the chance of a direct stroke to the line. The hazard of direct strokes to lines with high trees on either side of the right of way should be very small. It should be pointed out that a tree can direct a lightning stroke or "attract" lightning as readily as a metal tower because the charging takes place with small currents over a relatively long time. It also follows that the chance of any particular tower being struck does not depend upon its

footing resistance. The resulting voltage on the insulators following a hit does, however, depend almost directly on this resistance. Although a tree can "attract" a lightning stroke it cannot discharge it. Side flashes thus result.

Line voltages due to direct hits

When a line conductor is struck a very high voltage occurs across the insulators. It would usually be impracticable to use sufficient line insulation to resist such a voltage. However, when a tower or ground wire near the tower is struck the resulting voltage from line to tower or ground wire, or across the insulator string, is

$$V_s = KIR \qquad (3)$$

Where K is a constant depending upon the tower and ground wire configuration, I is the current in the tower, which will be less than the current in the stroke by the current in the ground wire, and R is the tower footing resistance; 0.80 may be taken as an average value of K for purpose of calculation.

From the formula it follows that it is important to keep the tower footing resistance very low if immunity from direct stroke sparkovers is to be hoped for. For example, if a lightning current of 250,000 amp. is assumed the voltage across the line insulators would be 2,000,000 for a footing resistance of 10 ohms. This is the sparkover voltage of fourteen to sixteen units.

The maximum voltage across the insulator at the tower struck is limited by the footing resistance, but the tail of the wave is rapidly reduced by reflections on the ground wire from the towers on either side. This reduction begins when the wave on the ground wire has traveled to the other tower and back. For a 1,000-ft. span the time is $\frac{2 \times \text{span}}{1{,}000} = 2$ microseconds; for a 500-ft. span it is 1 microsecond. The effect is that of applying a shorter wave across the insulators for the shorter span. Thus, when lightning strikes a ground wire with low ground resistance the voltage distribution is limited to a few towers. A ground wire thus reduces the chance of disturbance extending to apparatus.

Location of ground wire to shield conductors from initial hits

The ground wire or wires should be at a sufficient distance above the line wires to "attract" the lightning and thus take the initial hit. The shielding effect of a ground wire depends upon its vertical height relative to the line wire and to the horizontal distance between the projections of the two wires. If this horizontal distance is X and the vertical height of the line wire is h the ground wire should have a vertical height greater than y; y can be calculated from the equation

$$\frac{X}{H} = \sqrt{2\left(\frac{y}{H}\right) - \left(\frac{y}{H}\right)^2} - \sqrt{2\left(\frac{h}{H}\right) - \left(\frac{h}{H}\right)^2} \qquad (4)$$

which gives y and h for equal probability of being hit; y should be at least 10 per cent greater than the calculated value for protection of h. The only difference between the effect of a direct hit at the tower and one somewhere on the ground wire is that caused by the time taken by the wave to travel from the point hit to ground and for the reflected wave to travel back. This is so because the point struck is not affected by a ground until the reflected wave returns. Since the reflected wave is of opposite polarity it begins to reduce the voltage at this point upon its arrival. If the front of the direct stroke voltage is not steep enough to reach a dangerous voltage before the wave returns, sparkover will not occur between the ground wire and the line if the ground resistance is low enough. The time required for the return wave is one microsecond for every 1,000 ft. of complete travel. The maximum distance to the ground would occur for a hit in the center of the span. There are several ways by which this factor can be taken care of, as, for example: (a) Very high direct hit wires; (b) short spans or short distance between ground wire grounds; (c) a moderately high direct hit wire and a moderate length of span; (d) by separate towers or lines to take direct hits.

With the high direct hit wire the separation between ground wire and the line wire requires a longer time for the voltage to reach the sparkover value. Because of its height it is undesirable from the standpoint of "attracting" direct hits and not being very effective as a ground wire. With long spans 1,000 ft. or more and abrupt direct strokes the separation between this wire and the line or ground wire at the center of the span should be 25 to 50 ft. or more. Methods of stringing may permit greater clearance at the center of the span. It may usually not be necessary to design with excessive distance between line wire and ground wire to take care of a hit at the center of the span since the chances of such a hit are small. Experience indicates that even the usual ground wire separation is quite effective.

Low footing resistance can usually be obtained by means of buried wires connected to the tower legs. These wires may be either extended out radially from the tower or extended directly from the towers along the line. Radial wires of moderate length should usually be more effective. However, the method used will be governed largely by cost.

It is possible to prevent outages by some form of discharge device or diverter at the tower permitting the lightning to discharge freely to tower and ground, but preventing the power current from following. The fused grading shield, in which the discharge takes place from the shield through a fuse, is operating successfully in practice. The arc suppressor, a similar device in which the discharge takes place through a tube in which the dynamic arc is suppressed, is also being used. Other devices have also been successful, but they are still in the developmental stage.

Design of transmission lines to resist lightning

It is of interest, for the purpose of illustration, to apply the methods and information of the preceding sections to the design of a transmission line.

Assume that a practically lightning-proof line is required for operation at 230 kv. The best characteristics are obtained with a low line and short spans.

Assume:

Conductors in a horizontal plane; sixteen insulator units, sparkover 2,200 kv., ½/5 or 1 microsecond.

Average height above ground 50 ft.

Span, 500 ft.

Direct hit voltages

$$V_s = KIR = 0.80\,IR \qquad (5)$$

If 400,000 amp. is taken as the direct stroke current that is not likely to be exceeded except in the most severe cases, the corresponding maximum current in any tower is about 250,000 amp. At 10 ohms tower footing resistance,

$$V = 0.8 \times 250{,}000 \times 10 = 2{,}000{,}000 = 2{,}000 \text{ kv.}$$

For the steep wave this is just under the sparkover voltage of sixteen insulator units. Thus, the above insulation would be

highly resistant to the severest direct stroke if the footing resistance could be kept below 10 ohms. However, if the average current per tower is 100,000 amp. the footing resistance could be as high as 25 ohms without much trouble. If there are sections on the line where the resistance cannot be reduced to the desired value, special methods can be used, such as fused grading shields, or other diverting devices or by parallel wires on either side of the line.

Shielding the line wires from direct hits

It is now necessary to determine if the ground wires are high enough to shield the conductor from the initial hit. For $X = 10$ ft. and $h = 55$ ft. at the tower, y must be greater than 60 ft. Insulator lengths and other considerations have fixed y at 70 ft. The shielding condition is more than met without impairing the efficiency of the ground wires.

Direct hits to ground wires at center of span

To provide against direct hits from the ground wire to the line at the center of the span consideration of a further condition is necessary.

For the 500-ft. span the requirement is a minimum clearance of 20 ft. A somewhat greater clearance at the center of the span can probably be provided for without greatly reducing the ground wire efficiency.

Induced voltages

$$V = gh\alpha$$

If it is assumed that the highest α is 0.45 (10 microsecond discharge).

Then

$$V = gh\alpha = 100 \times 50 \times 0.45 = 2{,}250 \text{ kv.}$$

However, with ground wires

$$V = gh\alpha\omega$$

If

$$\omega = 0.5$$

Then

$$V = gh\alpha\omega = 1{,}125 \text{ kv.}$$

This voltage would not be greatly affected by the tower footing resistance until it reached a value of 50 ohms for the above line.

Thus with ground wires the induced voltage would probably not be a serious cause of trouble until seven or eight insulator units are used in a string.

These same methods can be applied to the design of other types of lines in the same way.

In wood-pole lines advantage should be taken of the insulating value of the wood to the fullest extent. The value of wood insulation to lightning voltages ($\frac{1}{2}/5$ wave) is about 180 kv. per foot.

The value of the ground wire for direct stroke protection as well as for induced voltage protection has been indicated in practice. This applies to the ground wire as usually located and for the high direct stroke wire, both of which have been experimented with on the lines of the Pennsylvania Power & Light Company. On one bad section of this line the outages were six, nine and fourteen respectively in the years 1926, 1927 and 1928. During 1929 the ground resistances on this section were reduced from 50 to 150 ohms to values of the order of one ohm and the usual ground wire was unchanged. There have been no outages on the section in 1929 and 1930. "Diverter" wires or high ground wires erected about 50 ft. over the line wires on another section have been struck without outages.

Direct strokes vs. induced voltages as a cause of outages

It is very difficult to decide definitely whether an outage is caused by induced voltages or direct strokes even when lines are equipped with instruments for that purpose. There is very good evidence that over 70 per cent of the outages on the 220-kv. (fourteen to sixteen insulator units) lines of the Pennsylvania Power & Light Company were caused by direct hits. A result of this order might be expected from the analysis above.

It is also seen that the chance of trouble due to induced voltages increases rapidly as the insulation is decreased.

On the lower voltage systems the hazard is increased in two ways. The percentage of voltages high enough to cause sparkover increases and the relative value of the insulation decreases. This decrease in the insulation value is due to the fact that the slow waves of the $1\frac{1}{2}/40$ type are high enough to cause flashover. The impulse ratio is much less for these than for the shorter waves.

Municipal Plants and Farmers' Taxes

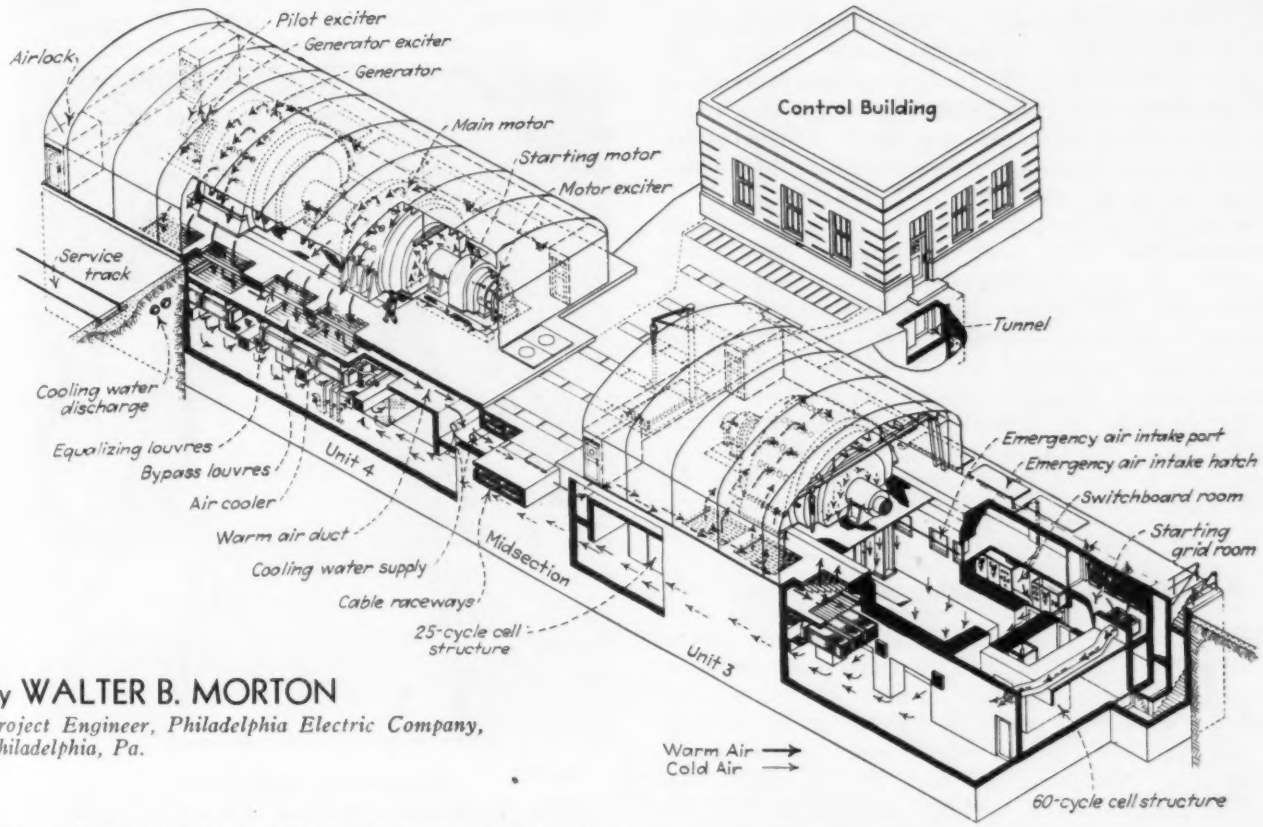
WHEN the government goes into business there is no hope of taxes from that source. That would be all right if all people were equally served by the government-financed activity, but what of the power plant, for instance, owned and operated largely within municipal limits? The farmer can have very little benefit from it, yet every dollar *not* paid in federal, state and county taxes by that utility is an added tax burden on the farmer. I have no complaint if municipalities want to own their utilities, but the ratio of state and county taxes to all taxes within the state is about 25 per cent in Nebraska, and farmers pay 65 per cent of all property tax. I want the municipally owned utilities to pay their share. In Nebraska there is more than $50,000,000 worth of municipally owned tax-exempt property that is used for business purposes. The farmer receives next to no benefit from this property. Why should he have his taxes increased on account of it?

"A brief excursion into wider fields indicates the extent to which farmers are being imposed upon by other government projects. It is proposed that $400,000,000 be spent on a reclamation project in eastern Washington. Another $500,000,000 would be spent in adding hydro-electric power to the project the benefits from which could not conceivably extend beyond Oregon and Washington. Boulder Dam is costing $165,000,000, for the benefit principally of southern California, not overlooking the fact that to the extent it increases agricultural production, it lessens the ability of farmers elsewhere to pay their taxes. Already $120,000,000 has been spent on Muscle Shoals and it is now urged that many millions more be spent with the government operating the project.

S. R. McKELVIE,
Ex-Governor of Nebraska,
to Middle West N.E.L.A. convention.

Pennsylvania Electrification
Converters Installed Outdoors

By WALTER B. MORTON
Project Engineer, Philadelphia Electric Company, Philadelphia, Pa.



Auxiliaries housed in foundation compartments

The three-foot thick bearing walls supporting the units also act as partitions for the rooms and compartments housing the auxiliaries. Air flow for ventilation and condensation control is indicated by heavy arrows for the warm air and lighter arrows for the cool air.

IN CONNECTION with the Pennsylvania Railroad's program of through electrification from New York to Washington, load studies and forecasts indicated the need for additional 60/25-cycle frequency converter capacity in the section served by the Philadelphia Electric Company. The site chosen for the new converter substation is adjacent to the Richmond steam generating station.

The initial installation at Richmond converter substation consists of two 30,000-kw. General Electric Company synchronous-synchronous indoor type frequency converters located outdoors under close-fitting steel plate housings. Previous experience with this type of outdoor construction applied to the 15,000-kw. units at Wayne Junction indicates that this departure from the use of an orthodox masonry building presents no difficult operating or maintenance problems, and represents an appreciable saving in building costs. The entire area within the foundation beneath the converters forms a large basement, which for the ultimate station will be approximately 500 ft. long. This basement contains all of the auxiliary equipment required for the units, except the cooling water circulating pumps which are located in Richmond generating station.

The ultimate design of the station contemplates a layout of six units, arranged end to end in two groups of three each. Between these groups and directly in line with the control building is a 30-ft. space which forms a passageway between the control building and the step-up substation and is used as a roadway for handling material. In the final station a single housing with partitions between units will enclose each group of three machines. The foundation area below the 30-ft. space is utilized for housing certain equipment common to all units, such as 2,300-volt sectionalizing breakers for starting motor feeds, generator neutral reactor with associated switching, sump pumps and oil-handling equipment.

Housing is under positive air pressure

Due to the difference in air pressure between the area within the housing and that in the basement, air locks, consisting of doors at each end of a short hall, are required to permit egress from the housing, which

is under positive pressure. Exterior doors in the housing are equipped with safety panic bars and latches for quick opening in emergency. Ely auto-balance doors facilitate opening of doors between the foundations of idle and running sets. Closing of these doors by differential relays prevents spread of fire in event of machine failure.

Three-phase, 60-cycle power is fed to each main motor direct from the 13.2-kv. isolated-phase buses in Richmond station. This, together with the use of 2,300-volt starting motors, eliminates the necessity for outdoor switching.

Each frequency converter set comprises a 36,000-kva., 13.6-kv., three-phase synchronous motor directly connected to a 30,000-kw., 13.2-kv., single-phase synchronous generator with two 200-kw. main exciters and a 7-kw. pilot exciter, all on the same shaft. The generator is equivalent in physical dimensions to a three-phase machine having an output of 61,000 kva.

The sets are so designed that they may be assembled or disassembled within their own length. By shifting the stator of either motor or generator toward the opposite stator it is possible to expose the entire length of either rotor without removing the inboard bearing of the opposite machine. In this way either motor or generator may be dismantled for repairs without disturbing the opposite machine. The stator frames are rendered easily movable on small rollers which may be inserted on a special roller track by first lifting the frame about one-half inch by means of screws provided for this purpose.

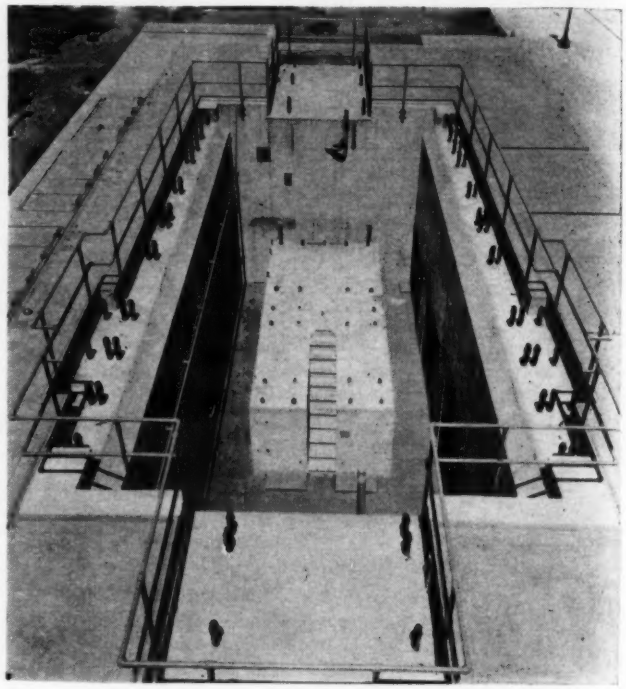
Third phase winding omitted

The cores of the generator stators are slotted similar to a three-phase machine, but the third-phase coils are omitted and the extra slots suitably closed, thereby effecting a substantial saving in the cost of the machine over one provided with a third phase for circulating current only. Successful operation of single-phase machines in parallel at the Lamokin and Wayne Junction substations indicated the practicability of parallel operation with the third-phase windings omitted entirely.

The starting system consists of a loop formed by two separate feeds from opposite sections of the 2,300-volt buses in Richmond, with disconnects and non-automatic oil circuit breakers between the taps to the starting motors. This dual source insures a high order of reliability in the starting system. The breaker in the center of the loop is normally open, which will ultimately place three machines on each feed. The initial demand of the starting motors is about 5,000 kva. The starting motors are not ventilated and are designed to operate in the 65-deg. F. ambient within the housing.

A Selsyn indicator on the miniature control board, calibrated in mechanical degrees, shows the position of the motor frame at all times. Limit switches prevent overtravel due to sticking of contacts or any other reason. As a safeguard against contact sticking, a tungsten alloy, "Elkonite," is used on the contact surfaces of control contactors. Mechanical stops, properly cushioned, stall the motor and prevent damage due to overtravel in the event that the limit switches fail to function.

The machines are ventilated with a closed cooling system. The heated air returns to the basement from the housing through water circulated air coolers. Six fin-type coolers of 26,000 cu.ft. per minute capacity are required for each set, three each for the motor and generator. Louvers operated by conveniently located handwheel mechanisms provide complete control of the air supply so that the coolers of any unit may be used for any other unit, thereby allowing maintenance of the coolers without necessity of machine shutdown. The total combined cooler area for motor and generator is 26,250 sq.ft. based on injection water at maximum temperature of 85 deg. F. Under these conditions 1,500 gal. of water per minute is required to cool the 150,000 cu.ft. of air from 65 deg. to 40 deg. C. The coolers are supplied through two 16-in. river water lines from Richmond station.



Foundations sunk 22 feet

Piling was bonded with a loop of 2-inch copper busbar and left as a permanent ground electrode. Concrete structure ribbed like a ship. High-density controlled-mix concrete relied upon for water tightness. Conduits and pipes brought through near grade level and turned down. Foundations for each set are 42x78 ft.

Valves and cross connections provide flexibilitiy in event of outage of either line. An emergency connection to the generator cooling water pumps in Richmond station is also provided. As an added safeguard to continued operation in the event of cooler failure, raw air may be admitted to the basement of a set through emergency doors, permitting indefinite operation as an open system.

With the outdoor installation, the maintenance of idle machines at temperatures sufficiently high to prevent the formation of injurious condensation would be a problem. This installation is designed so that an idle machine is kept warm by circulating through it heated air from a running machine. Louvers divert a portion of the 65-deg. C. air through longitudinal passages in the foundation to the housing of the idle set where the air passes through this unit in a reverse direction into the

basement, returning along the common passageway to the basement of the running set.

A perforated water-pipe type of fire protection is provided in each unit, terminating in a "snap coupling" outlet outside of the housing adjacent to a fire hydrant. A short length of hose is located near by for quick connection between the two in case of fire. The four main bearings are each equipped with individual 750-lb.-per-sq.in. lift pumps for use in starting the unit. Vibration, which is always prevalent to some extent in the normal operation of single-phase machines, is reduced to a minimum by means of springs under the 25-cycle stators.

Housings do not impede maintenance

The housings are composed of one-quarter inch steel plate shell shop-welded to fabricated "I" section ribs, and are shaped somewhat similar to the contour of the machine with suitable operating space provided on all sides. To facilitate shipment and handling during erection, as well as for convenient dismantling during maintenance periods, the housings are divided into nine sections, each consisting of two ribs and the connecting shell. Each section is further divided into three parts, the two lower vertical sides and the upper roof sector. Removal of the latter only is required for major repairs. Ordinary maintenance such as replacement of coils, inspection, etc., can be done without disturbing the housing. The roof sectors are 9 ft. by 36 ft. 6 in. and are sufficiently rigid to permit handling by crane. Lifting eyes are provided for this purpose at convenient points. Between the assembled sections are $1\frac{1}{4}$-in. spaces covered and sealed by clamping bands drawn against gaskets by frequently spaced bolts, the heads of which are welded to the bands. Rubber gaskets are used around door jambs and for the joints most frequently opened, while cork is used for joints not ordinarily broken. A one-inch cork cushion between housing and foundation prevents transfer of vibration to the housing.

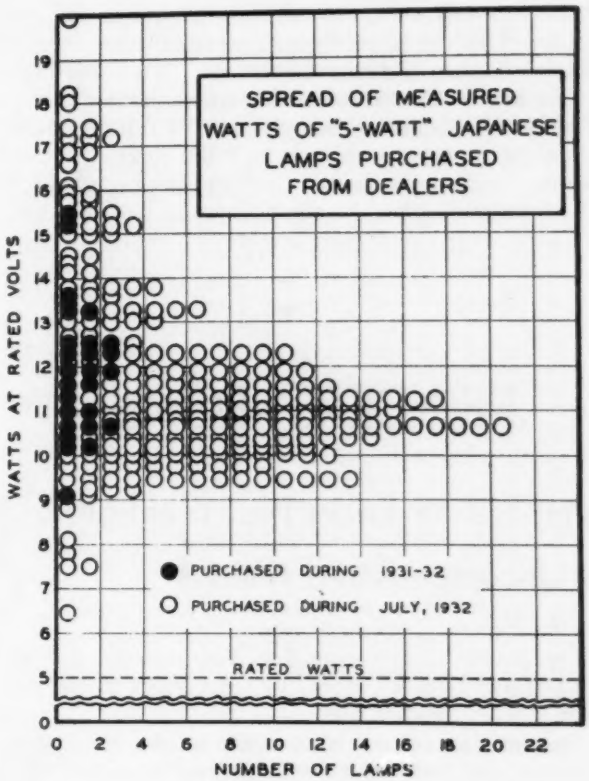
Due to the infrequent occurrence of major dismantling, power gantry cranes and other permanent rigging schemes were considered unnecessary. The sets were assembled by means of a 100-ton portable gantry crane equipped with a small travelling carriage for raising blocks and hoists into position. This crane, supplied by the erectors of the sets, is dismantled and stored where it will be available for later use at this and other similar stations. For handling end bells and other smaller parts during routine inspection and maintenance, longitudinal and transverse hand trolley hoists are provided within the housing. For handling parts, such as air coolers, to and from the basement, a three-ton jib crane is placed over a marine-type hatch located in the mid-section. This crane swings back against the nearby machine housing when not in use.

Only the switchboards which require the attention of an operator are placed in the control house, regulators, rheostats, machine relay panels and all similar equipment being located in the machine basements. The combining of a large group of control wires into a single cable effects an appreciable saving in cost by eliminating a considerable portion of the congested conduit system required for a similar installation using all conventional cables. Control circuits from the step-up substation are brought to the control building in conventional parkway type cables laid in concrete trenches.

The station was designed and constructed by United Engineers & Constructors, Inc., in collaboration with Philadelphia Electric Company engineers.

▼

Pseudo "5-Watt" Lamps


SPREAD OF MEASURED WATTS OF "5-WATT" JAPANESE LAMPS PURCHASED FROM DEALERS
WATTS AT RATED VOLTS
NUMBER OF LAMPS
PURCHASED DURING 1931-32
PURCHASED DURING JULY, 1932
RATED WATTS
0 2 4 6 8 10 12 14 16 18 20 22
0 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Incandescent lamps may and do vary with respect to light output and efficiency—qualities not designed on the lamp. The public, however, should be able to rely upon the substantial correctness of the watts designation which does appear on the lamp.

Recently Japanese lamps have been found upon the American market bearing "5-watt" designations. Electrical Testing Laboratories, on behalf of member companies of the Association of Edison Illumination Companies, having surveyed these products, finds that such lamps are anything but 5 watts, averaging about 12 watts and ranging as indicated in the accompanying chart.

Such misleading marking of incandescent lamps is inexcusable, these laboratories contend.

Measurements of Wattage of Japanese Lamps, Rated at 5 Watts, Purchased in Various Cities

City	Number Measured	Average Watts
Detroit	23	11.2
Warren	10	10.6
Boston	53	11.1
Philadelphia	24	11.8
Waterbury	11	11.9
New York	39	11.7
Chicago	13	13.9
Butte	2	11.1
St. Louis	37	12.5
Youngstown	2	13.4
	214	11.8

Cleaning Arc Lamp Reflectors

White porcelain arc lamp reflectors become covered in time with a brown deposit that cannot be removed by ordinary cleaning methods. Deposits as difficult to remove sometimes occur also on reflectors for incandescent street-lighting units. A cleaning process that is not new but which is not widely used in this field is employed by the street-lighting maintenance department of the Toledo Edison Company. Two earthenware crocks are used, one containing dilute hydrochloric acid and the other soda solution. A pile of reflectors are left overnight in the first crock and the next morning the cleaner, wearing a pair of rubber gloves, swabs them off in the acid. Then he rinses them in the soda solution and they appear clean and bright.

▼

READERS' FORUM

Temperature Errors Not Negligible in Uncompensated Meters

To the Editor of the ELECTRICAL WORLD:

The article "Correcting for Temperature Errors of Watt-Hour Meters" by G. W. Stubbings in the July 2 issue is timely and of interest.

Quoting from the first paragraph, "the effect of temperature variation on the accuracy of an induction type watt-hour meter is relatively small, . . . " From the graphs accompanying the article the conclusion would be drawn that the temperature errors are the same for all types of watt-hour meters, and the entire article leaves the impression that temperature errors of uncompensated watt-hour meters are not worth the trouble of correcting.

One of the greatest sources of error in the registration of uncompensated watt-hour meters is that caused by changes in temperature, and this applies to both single and polyphase. An uncompensated single-phase watt-hour meter that is calibrated during the summer is likely to run from 1.0 per cent to 4.0 per cent slow the following winter.

As stated by Mr. Stubbings, the effect of temperature error depends upon the power factor at which the watt-hour meter operates. Fortunately, in two-element polyphase watt-hour meters, these errors tend to have a neutralizing effect upon each other, for, contrary to the graphs shown by Mr. Stubbings, the temperature error for a load of 0.5 power factor lagging is negative.

The writer has made a number of tests of watt-hour test meters in which thermometers were inserted to obtain internal temperatures. Eighteen different meters were tested representing six different types from three manufacturers. The errors when plotted as curves were dissimilar not only for watt-hour meters from different manufacturers, but also varied with the types produced by each manufacturer, and no two curves were exactly alike, but for each watt-hour meter operating at 0.5 power factor lagging the error was negative. With a temperature change from 20 to 45 deg. C. or 68 to 113 deg. F. with loads of unity power factor the error was positive and varied from 1.0 to 2.6 per cent and with loads of 0.5 power factor lagging the error was negative and varied from 5.6 to 1.5 per cent.

Although the net effect of temperature errors on polyphase watt-hours may be small in terms of per cent, this point should be checked for each installation. As an illustration: A watt-hour meter registered approximately 6,000,000 kw.-hr. per month. Tests showed the net registration of this meter to be 0.5 per cent less at 7 p.m. than at 7 a.m. due to temperature changes. Assume that the registration was correct at 7 a.m. and that the temperature change was uniform both at a.m. and p.m., the average error would be 0.25 per cent; 6,000,000 × 0.25 =15,000 kw.-hr., which at 0.5 per kw.-hr. = $75. The net change in registration from the average summer temperature to the average winter temperature for this meter was 1.7 per cent.

For accurate registration the only satisfactory solution is to use the best compensated watt-hour meter available and then carefully calibrate it at the average or normal temperature.

The writer has written more fully regarding temperature errors in "Factors Affecting the Registration of Watt-Hour Meters," *Electrical West,* August, 1932.

J. P. SURRATT,
Foreman Meter Department.
Salt River Valley Water Users' Association,
Phoenix, Ariz.

▼

Air-Conditioning Opportunities

To the Editor of the ELECTRICAL WORLD:

I like your editorial "An Opportunity—Ice for Air Conditioning," appearing in the July 9 issue of ELECTRICAL WORLD. It is very timely and should be carefully read by all utility men.

Here in Philadelphia we are working very harmoniously with the Ice Producers Association. We have sincerely tried to understand each other's problems and, in this connection, we have directed the ice manufacturers' attention to the possibilities of increasing their sales through the use of ice for air-tempering as well as for those special and emergency needs not readily supplied by mechanical units. As a matter of fact, during this year we have developed several air-cooling jobs where the size of the installation justified the use of ice-cooling rather than mechanical refrigeration. These installations range from a daily consumption of six to eighteen tons and the results have apparently been entirely satisfactory.

In the last analysis, if the utility is doing a good job, practically all of the manufactured ice will be produced by electric power. This being the case, then the utility should have little need to concern itself as to whether it gets its revenue from the manufacture of ice or from the direct supply to mechanical units. We are in that position in the Philadelphia territory today and thus far have found it very easy to co-operate with the ice producers in the development of their business in spite of the fact that the respective fields of ice and mechanical units are highly competitive.

H. P. LIVERSIDGE,
Vice-President.
Philadelphia Electric Company.

Men of the Industry

ELLIOTT MCELDOWNEY has been appointed director of advertising and news of the Cities Service Company and Henry L. Doherty & Company to succeed Frank Le Roy Blanchard, who has retired. Mr. McEldowney was Mr. Blanchard's assistant.

•

MERRILL G. BAKER has been appointed executive assistant to the president of Blaw-Knox Company, Pittsburgh. For several years Mr. Baker was associated with Ford, Bacon & Davis, Inc., engineers, New York, in the capacity of assistant to the vice-president.

•

DONALD B. SISTARE has been named general manager of the Rutland division of the Central Vermont Public Service Corporation, succeeding Charles D. Spencer, resigned. Mr. Sistare has been executive assistant in charge of public relations at the Boston office of the Central Vermont and Twin State Gas & Electric companies.

•

G. W. VAN DERZEE, vice-president of the Milwaukee Electric Railway & Light Company, has been named a director and a member of the executive committee. Mr. Van Derzee has been associated with the company since 1913.

•

E. FRANK GARDINER, director of advertising and publicity for the Midland United Company of Chicago, was elected president of the Public Utilities Advertising Association at its recent convention in New York.

•

CHARLES M. COLYER, for the past two years in the Boston office of Stone & Webster Service Corporation, has recently been transferred to Porto Rico as sales manager of Ponce Electric Company. Mr. Colyer has been employed by the Stone & Webster organization since 1927.

•

W. C. BRADLEY of Columbus, Ga., chairman of the board of directors of the Coca-Cola Company and for many years prominent in Georgia banking and industrial fields, has been elected to membership on the board of directors of the Georgia Power Company. Mr. Bradley has been identified with the public utility industry for a long period, having served as a member of the board of directors of the Columbus Electric & Power Company since its formation. Since the merging of the Columbus property with the Georgia Power Company in 1930, he has served as a member of the advisory committee of the Georgia Power, a position which he resigned to accept membership on the board of directors.

▼

J. M. Barry Assumes Broader Duties

Resignation of Perry W. Turner as an executive of the Alabama Power Company has been announced by Thomas W. Martin, president. Mr. Turner, who has been connected in an executive capacity with the power company for two years, will be succeeded by J. M. Barry, vice-president of the company, who will be general manager with the title of vice-president and general manager. Mr. Barry assumed the executive duties of Mr. Turner, in addition to those he has hitherto performed, August 1. Mr. Turner will rejoin the law firm of Martin, Thompson, Turner & McWhorter, general attorneys for the power company.

Mr. Barry was graduated in electrical engineering in 1910 from the University of California. Leaving college he was foreman of underground construction for the Pacific Gas & Electric Company, Sacramento, for three years, going from there to Portland, Ore., to become electrical engineer with the Northwestern Electric Company.

From 1914 to 1917 he was chief of the department of electricity of San Francisco, and in 1918 became distribution engineer with the Great Western Power Company in that city, leaving there to become connected with the Alabama Power Company as eastern division manager in Anniston. In 1921 he was appointed assistant chief engineer of the Dixie Construction Company. Two years later he became manager of the southern division of the power company. Subsequently he was made manager of retail operation, at a later date assuming the duties of vice-president. In May, 1927, he became vice-president in charge of operation.

OBITUARY

Thaddeus R. Beal

Thaddeus R. Beal, president and general manager of the Central Hudson Gas & Electric Corporation, died suddenly on Wednesday of last week at the age of 68. He was spending his vacation with his family at Nantucket, Mass.

Mr. Beal had been an officer of the company since the organization of the original unit, the Newburgh Light, Heat & Power Company, in 1900. He had previously been superintendent of the Central Union Gas Company in New York City and had also been associated with predecessor companies in Newburgh. On November 16, 1900, he was elected secretary and treasurer of the Newburgh Light, Heat & Power Company, and was also made general manager in 1909. Since 1901 he had been secretary and general manager of the Poughkeepsie Light, Heat & Power Company, which was combined with the Newburgh company in 1911, when the Central Hudson Gas & Electric Company was formed, and at that time he was made secretary and general manager of the newly formed company. On August 17, 1912, he was elected president of the Central Hudson Gas & Electric Company, following the death of his father, who had been president since 1902. He became president and general manager of the Central Hudson Gas & Electric Corporation on January 1, 1927, the date when the present organization was consolidated, representing a total of 65 isolated companies which had been welded together to provide a unified service for the region.

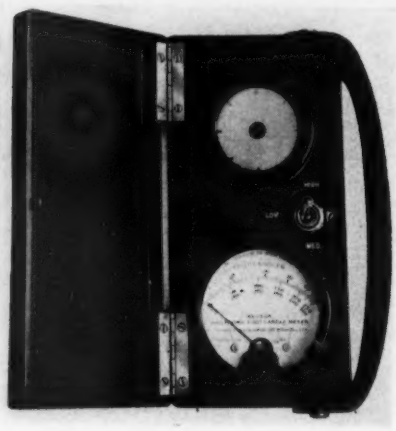
Previous to his entering public utility service Mr. Beal studied at St. Paul's School in New York City and the College of the City of New York, where he trained for the profession of engineer. He had many managerial connections with various national gas and electric organizations, and on November 3, 1931, was presented with the James H. McGraw award, through the Society for Electrical Development, for his co-operative efforts in developing electric service in his company's territory.

Mr. Beal, always active in community life, was for fifteen years president of the Newburgh Y.M.C.A. and at the time of his death was chairman of the board of that organization. He was affiliated with the following organizations: National Electric Light Association, American Gas Association, American Institute of Electrical Engineers, Society of Gas Lighting, Regional Plan Association, state executive committee of Y.M.C.A.'s of New York State, the Amrita Club, Engineers' Club, Powelton Club and Dutchess Golf and Country Club.

New Equipment Available

Foot-Candle Meter in Pocket Size

Among the many simplified photocell applications with various indicating instruments made possible through the use of the new Weston "Photronic" photoelectric cell is a recently developed pocket size foot-candle meter. This device has been built especially for lighting salesmen's use; calibrated to read directly on three ranges; 50, 250 or 500



foot-candles. One "Photronic" cell is used as an adjustable light collector, with readings appearing on a scale 2.36 inches in length. The cell and instrument are housed in a neat, black, moulded case, measuring approximately 3⅜x7x2¼ inches. A hinged cover and convenient carrying handle finish it in attractive form. Advantages include: Surveys may be made with utmost facility, values read directly in foot-candles, permanent calibration, restandardization unnecessary, quick response to slight variations in intensity, observer-errors minimized, and, no batteries, voltage or lamps.

▼

COVERING POWER REQUIREMENTS from 50 to 1,000 horsepower, in two to eight cylinder units, an improved standardized line of four-cycle direct injection moderate speed Diesel engines for stationary and marine services is announced by the Worthington Pump & Machinery Corporation, Harrison, N. J. The final design was established only after several years of experimentation and operation under actual working conditions. Among the many salient features are: Individual fuel pumps for each cylinder; individual air starting pilot valves; and spray valves, pressure actuated. All of these Diesels easily can be converted to operation on manufactured or natural gas—the same base, frame, crankshaft and connecting rod is used for both engines.

▼

Front-Operated Interlocking Double-Break Safety Switch

Front-operated interlocking double-break safety switches grouped to form class "A" dead-front safety type panels are announced by the Trumbull Electric Manufacturing Company, Plainville, Conn. The switch used in the various groupings is designed for severe use and frequent operation. For this reason nothing less than 60-amp. parts are used. The operating handle is made of metal.

The new quick-break feature consists of a strong spring placed where the drawbar joins the handle, so that when disconnection is nearly completed the spring literally snatches the blades from the jaws. The switch is constructed with a double break; that is, the circuit is broken in two places, which disconnects both the line side and the load side from the switch break. Breaking the circuit in two places reduces the arc materially. Furthermore, the blade leaves the jaws parallel to the top of the jaws, hence whatever arc is present is distributed over the full width of both break jaws, prolonging the life of the blade and jaws and practically eliminating the chance of the formation of destructive beads and pitted areas.

▼

QUICK-TRIP METERS of the graphic type which furnish a close-up picture of disturbances taken while they are happening are announced by the Esterline-Angus Company, Indianapolis, Ind. When any abnormal condition arises, in a few hundredths of a second the speed of the chart is multiplied 3,600 times, thus giving an extended record that tells its own story of the happenings during the brief interval of the disturbance. Normal chart speed is resumed immediately with return of normal conditions.

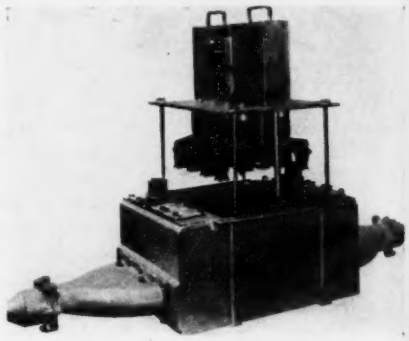
•

A COMPLETE PUBLIC ADDRESS SYSTEM so small that it fits into a suitcase and is carried around by hand is announced by the Western Electric Company, New York. The amplifier has a gain of 71 decibles, enough to magnify the speaker's voice from one to many thousand times its natural loudness according to the surroundings, it is claimed. The equipment includes the amplifier, a loudspeaker, a control unit and the necessary connections. It operates from the regular alternating-current electric power supply.

▼

Oil-Immersed Disconnect for Underground or Pole Line

A 7.5-kv., 600-amp. oil-immersed disconnecting switch for either underground or pole top service in which an important feature is the use of a steel plate which moves down with the switch blade mechanism grounding on the steel tank, placing a barrier between the switch contacts, is announced by Delta-Star Electric Company. A surge on the



live side of the switch sufficient to break down the oil goes to ground and cannot induce any voltage on the disconnected contacts, it is claimed. The switch mechanism mounted on top of the steel housing can be withdrawn for inspection. Load need not be dropped when the switch is removed from the tank.

▼

TIME SWITCH FEATURES in ordinary size tumbler switches have been extended for various special uses and services. M. H. Rhodes, Inc., Hartford, Conn., offers additions to early lines for appliances, ranges, refrigerators, oil burners, radios, parking lights, sun lamps, poultry industry, industrial machines and for one, two or three circuits.

•

UNIT HEATERS for industrial space heating which embody many new features of construction are announced by the Murray Iron Works Company, Burlington, Iowa. While these heaters are furnished with the usual motor drive, they are also marketing a heater with steam-turbine-driven fans which may be operated at steam inlet pressures as low as 12 lb.

•

AN AUTOMATIC ELECTRIC HOTBED HEATER which consists of a low-temperature heating element, mounted on a light, rust-resisting steel frame is announced by the Westinghouse Electric & Manufacturing Company. Its heat spreads out uniformly over an area of from 15 to 20 sq.ft.